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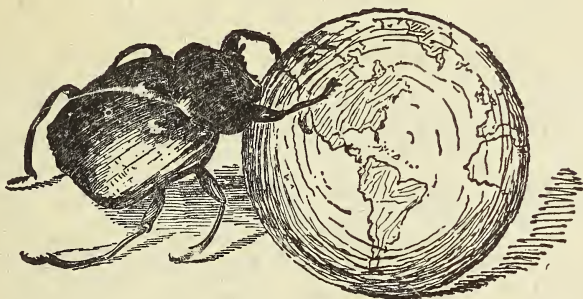
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No. 1

THE EFFECT OF HOST SIZE UPON THE SEX RATIO OF HYMENOPTEROUS PARASITES AND ITS RELATION TO METHODS OF REARING AND COLONIZATION

BY C. P. CLAUSEN

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UNITED STATES DEPARTMENT OF AGRICULTURE

It has often been assumed that the sex ratio is an approximately constant factor for any given insect species under field or laboratory conditions, and figures quoted for this relationship are usually based upon rearings of field samples of varying size, and collected, in most cases, at times of numerical abundance. The sex ratio of a species is in reality exceedingly variable and fluctuations may be due to a number of causes. It is proposed to discuss here some of the factors which bring about these changes, particularly among the parasitic Hymenoptera, and to discuss their bearing upon biological control work.

In general it may be stated that, in the parasitic Hymenoptera, either an approximately equal representation of the sexes or a preponderance of females is the normal condition in nature. Often there is a marked preponderance of females, extending in some instances to the occurrence of only an occasional male among thousands of females, and finally to those species in which reproduction is entirely thelytokous. Exceptions to the numerical dominance of the females may be noted, as in the case of *Opius melleus* Gehan (Lathrop and Newton, 1933), which showed 37.68 per cent females among 4,962 adults reared from field-collected

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Rhagoletis pomonella Walsh over a period of three years. Pemberton and Willard (1918) record only 37.6 per cent females among 26,975 adults of *Opius tryoni* (Cam.) reared from field-collected puparia of the Mediterranean fruit fly (*Ceratitis capitata* Wied.) during two seasons.

The sex ratio is often a rapidly changing figure for a species during the season. *Microterys clauseni* Comp., a gregarious internal parasite of *Ceroplastes floridensis* Comst., in Japan showed the females of the overwintering generation predominating 3:1, whereas in the following generation, emerging in June, the ratio increased to 9:1. Even more striking is the variation shown to occur in *Tiphia popilliavora* Roh. (Brunson, 1934), a solitary external parasite of the larvæ of the Japanese beetle (*Popillia japonica* Newm.). In this instance the ratio of the adults developing from eggs laid during August was 1:2.8, the males predominating, whereas among those from eggs laid during September and later the females predominated 1.5:1.

One of the important factors influencing the sex ratio is the size of the individual hosts in or upon which the parasites develop. Attention was called to this fact by Chewyreu (1913), who found that the great majority of *Pimpla* spp. from large cocoons were females, whereas those from small cocoons were predominantly males. The large-sized hosts of *Pimpla* spp. (mainly *instigator* F.) are of the lepidopterous genera *Sphinx*, *Saturnia*, and *Gastropacha*, and the smaller species are of *Pieris*, *Panolis*, and *Bupalus*. Field-collected pupæ of the larger species yielded a large majority of *Pimpla* of the female sex, while the small pupæ produced mainly males. Laboratory tests verified these findings, large host pupæ yielding 100 per cent of female parasites and the small ones 80 per cent of males.

Exenterus sp. from *Lophyrus* cocoons yielded 79 per cent of females from large host cocoons and 47 per cent from the small cocoons, while the corresponding figures for *Campoplex* were 70 per cent and 26 per cent, respectively. In the case of this host the male cocoons are approximately half the size of those of the females.

Chewyreu attributed the marked disparity in the sex ratio of *Pimpla* to selective oviposition by the parent female. According

to this hypothesis the female is able to deposit fertilized or unfertilized eggs at will, and those destined to produce females are placed in the larger hosts, which provide a greater food supply for the progeny. This explanation of a very interesting phenomenon has been questioned by several authors and a direct nutritional basis offered instead. Others suggest that mated females are attracted to the larger hosts and unmated females to the smaller ones. It is quite possible that a single explanation will not suffice for all cases of fluctuating sex ratio arising from differences in size of the host individuals. At this time, however, we are not concerned so much with the causes which bring about this condition as with the application of the knowledge of these facts to the practices of biological control.

Further information regarding the sex ratio in the Ichneumonidæ is available in the literature. Seyrig (1935) discusses *Pimpla maculiscaposa* Srg. and *Echthromorpha hyalina* Sauss. Both of these species have many lepidopterous hosts and the pupæ of the largest species are approximately 20 times as large as those of the smallest species. The largest pupæ yielded almost exclusively females, whereas from the smallest hosts the males predominate in the ratio of about five to one.

In the case of *Exeristes roborator* F., a solitary parasite of the larva of the European corn borer (*Pyrausta nubilalis* Hbn.), W. A. Baker advises me that insectary rearing on this host at the Toledo, Ohio, laboratory during 1924-27, representing 100,000 individuals, gave a sex ratio of 1:1.13, the males predominating. This ratio varied from 1:1.63 to 2.45:1 in different years and there was considerable variation during the course of each year. Fox (1927) states that in Canada the ratio for insectary-reared material of this species was 1:2, the males predominating, and that difficulty was experienced in maintaining a satisfactory production of females. More recently this parasite has been reared upon the pink bollworm (*Pectinophora gossypiella* Saund.) at the Presidio, Tex., laboratory. According to unpublished reports by L. W. Noble, reproduction upon this host, which is smaller than the European corn borer larva, resulted in a sex ratio of the progeny of 1:8.5, the males predominating. Emergence of material which developed in the field revealed a ratio of 1:4.1. The

possibility of securing a higher production of females by the use of a larger host was investigated and the southwestern corn borer (*Diatraea grandiosella* Dyar) was utilized for this purpose. This change to a larger host was reflected in the sex of the progeny, and resulted in the more favorable ratio of approximately 1:2.

In *Calliephialtes messor* (Grav.), a solitary external parasite of the larva of the codling moth (*Carpocapsa pomonella* L.), Cushman (1913) records the females as being in the minority to the extent of 1:3 among 528 progeny reared from mated females under insectary conditions. The overwintering brood showed a ratio of 1:2.5, and this declined in the third following generation to 1:8.8.

The above decline in the proportion of females, when reared in the laboratory, has been duplicated with many species imported from abroad. A striking instance is cited by Bradley and Burgess (1934) in the case of *Cremastus flavoorbitalis* (Cam.), a solitary internal parasite of the larva of the European corn borer in the Orient. The field-collected material which was imported showed the number of females to exceed that of the males by 1.6:1. In contrast to this, the results of rearing under insectary conditions, with apparently mated females, practically reversed the ratio, the females being in the minority in the ratio of 1:2.2.

Among the Braconidæ some striking figures have been presented by Holdaway and Smith (1932) for *Alysia manducator* Panz., a solitary parasite in the puparia of blowflies in Europe. The hosts studied were *Calliphora vomitoria* L., *Sarcophaga* spp., *Calliphora erythrocephala* Meig., and *Lucilia sericata* Meig., given in the order of relative size. The largest *C. vomitoria* puparia produced females only and the smallest *L. sericata* males only. The proportion of females increased in simple proportion to the increase in size of puparia. This held true within each species as well as between different species. In the larger puparia of *L. sericata* the sex ratio of the parasite was 1:1.3, the males predominating, whereas from the smaller puparia the ratio was 1:5.1. From puparia of *Sarcophaga* spp. the ratio was 2.1:1.

Another solitary parasite of blowfly puparia is *Brachymeria fonscolombei* (Dufour), which has been studied by Roberts (1933). Very extensive rearings were made during 1930-32 and

the sex ratio of all emergences was 1.3:1, the females predominating. It is noteworthy, however, that one rearing revealed a female preponderance of 3.5:1, whereas another showed a deficiency of 1:2.3. It would appear probable that this difference was due to the different numerical abundance of host species, which in turn vary greatly in size, in the respective trap jars.

In the Trichogrammatidæ, represented by *Trichogramma evanescens* Westw., we find the sex ratio responding markedly to a shortage of food resulting from superparasitism. Salt (1936) has shown that where a single female is confined with a given number of host eggs 77.6 per cent of the progeny which emerge are females. Further similar tests, increasing the number of parent females but retaining the same number of available host eggs, revealed a consistent decrease in the proportion of female progeny. The extreme superparasitization induced by confining 50 parent females with 100 eggs yielded only 43.8 per cent female progeny.

Flanders (1935) points out that *T. evanescens* showed females predominating to the extent of 2:1 when developing in the eggs of *Estigmene acraea* (Drury). These eggs are sufficiently large to permit a maximum of 10 individuals to complete development in each. At least three *Trichogramma* eggs may be deposited at one insertion of the ovipositor and these normally produce two female and one male progeny. If only a single egg is laid the progeny is invariably female. Large females may be over five times as prolific as smaller individuals. This difference in size may result in the individual females selecting different hosts, as the smaller females are unable to penetrate as thick-shelled eggs as are the larger individuals.

Taylor (1937) has presented evidence regarding two chalcidoid parasites of coconut leaf-mining beetles of the genus *Promecotheca*, and shows a marked change in the sex ratio in relation to size of host. In *Pleurotropis parvulus* Ferr., from first-instar host larvæ only, the females predominated in the ratio of 1.66:1.00, whereas on third-instar hosts the preponderance of females increased to 4.34:1.00. A similar situation was found to exist with respect to *Elasmus hispidarum* Ferr. Among those developing on first-instar hosts the females were in the minority to the

extent of 5:7, whereas on mature host larvæ they predominated in the ratio of 2:1.

Brunson, in the publication already referred to, has given an account of an exceptional variation in the sex ratio induced by a difference in size of hosts. *Tiphia popilliavora* Roh. is a solitary external parasite of the Japanese beetle imported from the Orient some years ago. It normally attacks third-instar hosts, but under field conditions in the United States it emerges and is ready for oviposition so early in the season that very few third-instar grubs are available, the great majority being still in the second instar. Collections of parasitized grubs made during August and held for emergence of the parasite showed a sex ratio of 1:93, the males predominating, from small second-instar grubs, 1:28 from all second-instar grubs, and 2:1, the females predominating, from hosts in the third instar.

More recently (1937) the same author has presented further information on this subject. Eggs deposited on small grubs were transferred to third-instar grubs for hatching and development. Even with the greater amount of food available the sex ratio of the progeny remained virtually identical with that from small grubs. Transfer of eggs from large to small grubs likewise effected no change in the sex ratio. It thus appears that the sex of the progeny is determined by the female at the time of oviposition, a great preponderance of fertilized eggs being placed upon third-instar grubs and of unfertilized eggs upon those of the second instar. These findings corroborate the conclusions reached by Chewyreu in the case of *Pimpla*.

Another phase of the sex-ratio problem is presented by Flanders (1936) in connection with his studies on aphelinid parasites of scale insects. Certain of these species develop as both primary and secondary parasites and several authors have pointed out that the individuals developing in the latter rôle are invariably males. Flanders now finds that in certain species of *Coccophagus* the males can be produced only hyperparasitically, whereas the progeny from the coccid host are exclusively females. Related to this phenomenon is the fact that the oviposition response of the parent female changes at the time of fertilization. When unmated she is attracted only to previously parasitized scales, and

places her egg only in the body of the primary parasite larva, whereas after mating she oviposits only in unparasitized scales. In those groups in which this relationship is not obligatory the host of the hyperparasitic male, being smaller than the coccid host, may govern the sex of the parasite.

From the data presented it will be seen that the idea of the sex ratio of any given species being even approximately a fixed figure is entirely untenable. It will vary (1) with the sex ratio of the host; (2) with successive generations upon the same or a different host generation; (3) with different hosts; (4) upon the same host and in the same season, but in different geographical regions; and (5) in successive years when the host population is increasing or declining rapidly. Increase in host density is often reflected in a reduction in size of individuals, with a consequent influence on the sex ratio of the parasite. Theoretically the greatest opportunity for a constant sex ratio should be in a monophagous parasite species of solitary habit, such as *Chelonus*, which oviposits in the host egg and develops in the larva, in a host species having a minimum difference in size between the sexes and a single generation each year.

It follows logically that the value of any quoted sex ratio is dependent upon the supporting data accompanying it. This should include the sex ratio of the host generation upon which the parasite developed (applicable when both sexes are attacked), the stage of the host (applicable only when attack is not restricted to a single instar), the locality of collection, and the dates of rearing. When possible, separate figures should be given for those reared from each host sex and for each parasite generation during the season.

The facts presented illustrate quite clearly the great influence which the factor of size of host exerts upon the sex of the parasite that develops upon it. In some cases, though by no means in all, this information can be applied in a practical way in biological control work involving the rearing, in the insectary, of stocks for colonization. A higher ratio of females will permit of a more rapid increase in number of the rearing stock or, conversely, it will permit the production of a given number of females for colonization at a lower cost and with less labor.

Among those monophagous parasites which reveal a change in

sex ratio correlated with host size, advantage should be taken of this opportunity by the use, when possible, of later host instars or, in the case of cocoon parasites, of female cocoons only if there is an appreciable disparity in size between those of the two sexes.

In the case of polyphagous species the opportunity of securing increased production is even greater. Here it is possible not only to utilize the larger individuals of the principal host species, but to make a complete change of hosts for rearing purposes, the species selected being the one of maximum size and greatest availability among the known hosts.

It has been demonstrated in a number of instances that the total number of eggs deposited by females of a given species is in simple proportion to their size. In rearing work the use of large hosts has an added advantage. Not only is the proportion of female progeny higher, but their reproductive capacity is greater, thus permitting a still more rapid build-up of stocks for colonization purposes.

One very important problem in many biological-control projects is the decline in proportion of females in successive generations when reared under insectary conditions. In a number of instances this has led to the final loss of breeding stock. Where this difficulty is encountered particular attention should be given to host size to determine if a selection of host stages or a change of host will lessen or overcome the tendency towards excessive production of male progeny. This tendency apparently is not always due to lack of proper mating.

Another way in which this relation between host size and the sex ratio of parasites can be put to practical use is in the time of colonization of introduced species. Where the parasite normally attacks its host in several larval instars it may prove to be a distinct advantage to make releases when the later instars predominate in the field. With polyphagous parasites the initial liberations might be advantageously made upon a host different from the one for which control is sought.

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BOOK NOTICE

Marvels of the Insect World. By Jean Henri Fabre. Edited, annotated and translated by Percy F. Bicknell. 12mo., cloth, 239 pp., illustrated with wood engravings by Robert Gibbings. N. Y., Appleton-Century Co., 1938. \$2.50.

The story of Jean Henri Fabre is so very well known and the various volumes and editions of his writings on entomological topics are so popular with the reading public that this, still another compilation from his writings, is quite certain to get a warm welcome. Fabre preferred to be called a naturalist rather than merely an entomologist; all nature was his province, including human nature. He was no narrow specialist. This gives to his printed pages a wide appeal. It also gives his writings additional breadth and fullness, and adds a unique maturity to his thought and utterance. His long life of some ninety-two years was devoted to the things of the intellect and the spirit. Nothing was ever permitted long to turn him away from his chosen pursuits, or his quiet, patient efforts to wrest from nature some of her obscure secrets. An idea of the general scope of the book under consideration may be gained by an enumeration of some of the more important subject subdivisions, such as: About insects; singing insects; metamorphosis; birth of the stag-beetle; sheath-winged insects; the sacred scarab and other beetles; butterflies; butterfly courtship; honey-bees; royal cells; swarms; ants; Amazon ants; flies and mosquitoes; bluebottles; oddities of natural history; spiders; ways of wasps; the eating habits of insects, and other topics of like kind. All those who have read other popular writings by Fabre along similar lines and pertaining to like topics, and who may admire the clearness of his literary style as well as the personal note struck here and there by the author—all those readers will get similar enjoyment from this little book. Its reading is commended.—J. S. W.

THE ANIMALS ASSOCIATED WITH EDIBLE FUNGI¹

BY C. A. THOMAS

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During the course of several years' investigation of the biology and control of the insects and mites affecting cultivated mushrooms, the writer has observed and collected a large number of insects and related animals from manure piles and from the interior of mushroom houses. Of course all these have not been species which are injurious to the mushrooms, as many were merely transported into the houses with the manure. Some of the species, however, are undoubtedly potential mushroom pests, since they have been found feeding on wild mushrooms and other fungi outdoors.

The following annotated list shows not only those species which the writer has found, but also those identified and recorded by mushroom insect research workers throughout the world. Noteworthy among the latter should be mentioned the work of Austin, Jary, Pitcher and Stapley in England; of Ripper in Austria, and of Okada in Japan, while in the United States, Compton, Davis, Gahm and Popenoe have been the principal contributors to our knowledge of the fauna of cultivated mushrooms. Weiss has written a number of interesting papers on the insects inhabiting various fungi, but has not confined his observations to those fungi which are edible. The present paper deals almost exclusively with those animals affecting fungi which are used as human food, whether wild or cultivated artificially.

In the United States and in England the chief cultivated mushroom is the common Field Mushroom, *Psalliota* (*Agaricus*) *campestris* (L.) Fr. In Japan, however, the principal edible species are the "Matsutake," *Armillaria edodes* Berk., and the "Shiitake," *Cortinellus shiitake* P. Henn., the first of which grows wild about pine trees, while the second is artificially grown on oak logs. Another, small brown mushroom called

¹ Authorized for publication on March 8, 1937, as paper No. 763 in the Journal Series of the Pennsylvania State College Agricultural Experiment Station.

"Nameko," *Pholiota nameko* (T. Ito) S. Ito & Imai, is also raised, largely for canning and exporting. While *Psalliota campestris* raising has developed rapidly in the past few years, most of them are canned and exported, some even coming to the United States. Okada's papers describe the principal insects affecting these fungi in Japan. Other fungi growing wild, and consumed by humans in various countries, are Morels (*Morchella* spp.), Puffballs (*Calvatia* spp.), Ink Caps (*Coprinus* spp.), *Russula* spp., *Lepiota* spp., and the Truffles of Europe, and many others, all infested by numerous insects which might feed on cultivated mushrooms.

As noted above, insects and mites may enter the mushroom houses in a variety of ways. Some of the mites, as the tyroglyphids and gamasids may come to the composting ground in manure on cars from the stables. Other mites, and most of the springtails, begin to enter the manure soon after it is piled on the ground, and gradually increase in numbers there. In the United States many adult phorids are found in and about these compost piles, while generally the adult sciarid flies are much less common there. Austin and Jary have found the same conditions to be true in England. Yet, in the United States, the sciarids are normally the most destructive mushroom pests. Some of the adults and larvæ undoubtedly enter the houses with the manure, but many are also attracted into the houses from adjacent infested houses and manure piles by the odor of the growing mycelium.

In addition to the direct injury to the mycelium and the growing mushrooms by these pests, it has been shown by Charles and Popenoe ('28) that the flies may transport mold spores on their bodies. The hypopial stage of the tyroglyphid mites is also frequently spread throughout mushroom houses by becoming attached to the bodies of flies, beetles, gamasid mites, etc. The present list contains not only those species which actually feed on some stage of the fungi, but also the predators and parasites which feed on these injurious species.

Appended is a bibliography listing practically all the papers concerning mushroom insects, except economic papers, which latter may be found in "Mushroom Insects, their Biology and

Control," Bulletin 270 of the Pennsylvania State College Agricultural Experiment Station, 1931.

The late C. H. Popenoe, during his work on mushroom insects for the United States Bureau of Entomology, collected a large number of species of mushroom insects, some of which are undoubtedly not listed in this paper. His specimens are now scattered through the U. S. National Museum collections.

The writer is greatly indebted to the following for specimen identifications and other courtesies: To the late Dr. J. W. Folsom, U. S. Bureau of Entomology, and Mr. Charles MacNamara, Arnprior, Canada, for the identification of numerous springtails; Dr. H. E. Ewing, U. S. National Museum, mites; Dr. O. A. Johannsen, Cornell University, sciarid flies; Dr. J. R. Malloch, U. S. National Museum, phorid flies; and Dr. E. P. Felt, Bartlett Research Laboratories, cecidomyiids.

NEMATHELMINTHES

Nematoda

Rhabdites teres Schnr.—Eelworm, Nematode—Austin 1933b, '34; Austin & Jary '34.

"Found just below the epidermis of the mushroom cap, where there was a marked breakdown and discoloration of the tissues. May be secondary."

R. lambdiensis Maupas—Thomas '31; Steiner '33; Haseman & Ezell '34; Gahm '32a, '35; Davis '35a.

According to Steiner, this nematode is an agent in the spread of *Bacterium* (*Pseudomonas*) *tolaasi* Paine, the cause of a spot disease of mushrooms. Haseman and Ezell give an account of this pest and methods for its control.

MOLLUSCA

Limax maximus L.—Spotted Garden Slug—Falconer 1897; Busek 1902; Duggar '04; Popenoe '12, '17, '25; White '18; Symes & Chorley '21; Stewart '26, '27; Thomas '31; Davis '35a.

Occasionally found in mushroom houses, but not a common pest.

ARTHROPODA

Crustacea

Armadillidium vulgare Latr.—Greenhouse Pillbug—Falconer '97; Duggar '04; Popenoe '12, '17, '25; Symes & Chorley '21; Ripper '30; Gahm '32a, '35; Davis '35a (undetermined sp.).

Porcellio laevis Koch—Dooryard Sowbug—Popenoe '12, '17, '25; Ripper '30; Thomas '31; Gahm '32a, '35; Jary '34.

P. scaber Latr.—Symes & Chorley '21; Ripper '30; Jary '34.

Oniscus asellus L.—Sowbug—Symes & Chorley '21; Ripper '30; Austin '33b, '34; Jary '34.

According to Austin, "sowbugs in England feed on mycelium and eat holes in the mushrooms, and are sometimes abundant in the beds, especially in brick buildings." Although common in mushroom houses in the United States, they are usually not so injurious here.

Sowbugs, undetermined species—Güssow & Odell '27.

Diplopoda

Blaniulus guttulatus Bosc.—Millipede—Austin '33b.

Choneiulus palmatus Němec—Rolfe '34; Jary & Austin '35.

The above two species ate holes in mushroom caps and stems.

Cylindroiulus britannicus Verh.—Jary & Austin '37.

Mushrooms in England were heavily infested with this millipede.

Nopoiulus pulchellus Leach, *Brachyiulus pusillus* Leach, and *Chromatoiulus unilineatus* Koch were recorded by Ripper '30.

Symphyla

Scutigera immaculata Newp.—Symphid; Greenhouse or Garden Centipede—Parks '30.

Parks recorded this centipede as injuring mushrooms in Ohio. This seems to be the only record of it as a mushroom pest.

Centipedes (unnamed)—Noted as predatory on *Tyroglyphus mycophagus* in England—Symes & Chorley '21.

ARACHNIDA

Acarina: Mites*Eupodidæ*

Linopodes antennæpes Banks (*motatorius* L.)—Gahm '30b, '30bb, '30c, '32a, b, '35; Thomas '31, '34; Compton '33, '35; Davis '35a; Ripper '30, '31; Austin '37; A. & Jary '37.

These long-legged mites sometimes cause much injury by feeding on the bottom of the mushroom stems, causing them to become reddish and constricted, and stopping their growth. They are apparently quite local in distribution. According to Austin, in England this species is often present, but apparently not abundant, in mushroom houses. Ripper states that it attacks *Coprinus atramentarius* as well as *Agaricus campestris*.

Eupodes sp.—Davis '35.

“Abundant in mushroom gills, Pomeroy, Pa.”

Bdellidæ

Undetermined species are predacious on springtails—Thomas '31.

Tarsonemidæ

Tarsonemus sp. (possibly *T. floricolus* C. & F., according to H. E. Ewing)—Miller '25; Puntoni '31; Davis '36.

Determined in 1936 as causing injury to mushroom caps and stems in Pennsylvania, turning the external tissues rusty brown, much in the manner of *Linopodes*. Found in the vicinity of Kennett Square and Oxford, Chester County, Pa. Puntoni found a *Tarsonemus* species (probably *T. floricolus* variety) infesting fungus cultures in Rome. Miller noted mushrooms among the food materials infested by Tarsonemid mites.

Pigmeophorus americanus Banks—Davis '35; Thomas.

Davis stated that these mites attacked the spawn in his cultures. This species has been abundant in certain mushroom houses in the Kennett Square, Pa., area in 1936-37. It did not seem to injure the mushrooms, but fed on the mycelium under the casing soil.

Tyroglyphidæ

Tyroglyphus lintneri Osborn—Osborn 1893 (original description); Lintner '94; Busck '02; Popenoe '12, '17, '25; Banks '06, '15; Weiss '15; Thomas '26, '29, '31, '34; Caesar '27; Ripper '30; Gahm '30a, b. '32c, '35; Stapel '32; Compton '33, '35; Davis & Young '34, '35; Davis & Claborn '35; Davis '35a; McCarthy '36; Swan '37.

These tiny mites feed on the spawn pieces, the growing mycelium, and make holes in the caps and stems. These holes are moist and dirty. Hypopi of the various Tyroglyphid species are frequently carried on the legs of the Sciariid and Phorid flies and on the Gamasid mites, thus being spread from house to house. The injury to mushrooms is not common in Pennsylvania.

Tyroglyphus longior Gerv. (*Tyrophagus putrescentiæ* Schr.)—Davis '37.

All specimens taken by Davis on cultivated mushrooms in Washington, Illinois and Pennsylvania were a species identical with *T. longior*, rather than *T. lintneri*, the species usually recorded.

T. dimidiatus Herm. (*Tyrophagus putrescentiæ* Schr. and var. *castellani* Hirst)

Previously known only from copra fibre, caused injury to mushrooms in England in 1937, according to Jary and Austin '38. Speyer '37 stated that this mite (= *longior* Gerv.) caused typical injury to mushrooms in Worthing. Jary and Stapley '37 described all stages of this mite, and Jary '37 gave the characters differentiating *T. dimidiatus* and its variety *castellani*.

T. mycophagus Megnin—Symes & Chorley '21; Austin '33b; Jary '34; Austin & Jary '34; Bul. 34, Min. Agric. & Fisheries.

Common, injuring mushrooms in England. Symes and Chorley state that it has been known to ruin mushroom beds, particularly those protected by straw.

T. (Aleurobius) farinæ DeG. and *Glyciphagus cadaverum* are sometimes serious pests of fungus cultures, according to Jewson and Tattersfield '22. Austin '37 found this species associated with compost but not with the growing crop.

Rhizoglyphus phylloxerae Riley—Banks '06; Gahm '30b, '35; Thomas '31, '34; Stapel '32; Davis '35a.

Occasionally found feeding in the spawn pieces in the beds.

R. spinitarsus—Symes & Chorley '21.

Reported as destroying mushrooms in a cave at Reigate.

Cosmoglyphus (*Caloglyphus*) *krameri* Berl.—Austin & Jary '34, '35; Jary & Austin '35.

The most common and destructive mushroom mite in England. May ruin the mushrooms as well as the mycelium.

Histiostoma (*Chortoglyphus*) *gracilipes* Banks—Banks '06; Gahm; Compton '33, '35; Thomas '34; Davis & Young '34, '35; Davis '35a; Davis & Claborn '35.

This mite feeds on the mycelium in the beds and on the growing mushrooms, especially on those somewhat injured. Compton states that this mite is very destructive in Illinois, causing more damage to mushrooms than do the *Linopodes* or *Tyroglyphus* mites. The hypopi of this species sometimes pile up in immense numbers on the casing soil and mushrooms, and are then easily spread by flies. Such piles are light reddish brown in color. The hypopi are not very active.

H. rostro serratum Megnin—Lintner '94; Symes & Chorley '21; Jary & Stapley '36.

According to Symes and Chorley this mite has been recorded as injurious to mushrooms in Paris, but Jary and Stapley said that it did not injure mushrooms in England, though common in the beds.

H., species undetermined—Thomas '29, '31.

Probably *H. gracilipes* Banks. Found nearly immersed in the watery liquid on rotting mushrooms; probably secondary.

Pediculoides, n. sp.—Symes & Chorley '21.

Caused a slight dermatitis to men working on mushroom beds.

Gamasidæ (*Parasitidæ*)

Parasitus (*Gamasus*) *ancoriferus* Oudemans.—Ripper '30.

Species of this genus are predacious on springtails and mites, and are sometimes very abundant in the compost piles and mushroom houses.

P. celer Koch and *P. fossorius* Berl.—Ripper '30.

Parasitus, undetermined species—Austin '33b.

“Observed attacking *Tyroglyphus mycophagus* Megn.”

Gamasids, undetermined—Popenoe '12, '17, '25; Symes & Chorley '21; Thomas '31; Gahm '35.

Zschachia littoralis Oudms. and *Coprobiaspis* sp.—Ripper '30.

Oribatidæ

Oppia (*Dameosoma*) *nitens* Koch—Ripper '30, '31; Austin & Jary '34; Bul. 34, Min. Agric. & Fisheries.

Ripper stated that this mite feeds on mushrooms near Vienna, but is not noticeably injurious.

Mites, undetermined species—Falconer '97; Duggar '04; Güssow & Odell '27.

HEXAPODA; Insects

Collembola: Springtails

Springtails are usually common, frequently very abundant, in mushroom houses, and generally are worse in the humid, even-temperated conditions of caves and coal mines where mushrooms are sometimes grown. Here they feed on the growing mycelium and on the mushroom caps and stems. They frequently also cause much damage by eating all of the mycelium in the spawn pieces, necessitating replanting. Some species are very strongly positively phototropic, gathering in immense numbers in groups or piles in the mushroom house aisles soon after the manure has cooled in the beds. Springtails are among the major pests of mushrooms.

Achorutes (*Hypogastrura*) *armatus* Nic. and variety *inermis* Axels.—Popenoe '12, '17, '25; Folsom '16, '33; Headlee '16; MacNamara '19a; Symes & Chorley '21; Theobald '29; Thomas '29, '31, '34, '35; Ripper '30; Austin '33a; Austin & Jary '34, '35; Gahm '32a, '35; Jary & Austin '35, '37; Compton '36, Swan '37.

This is the common so-called “Mushroom Springtail,” although in Pennsylvania it is generally less destructive than some *Isotoma* and *Lepidocyrtus* species. It is found throughout the world, and is apparently a bad pest in England. The injury

consists in feeding on the mycelium and chewing holes into the cap and stem surfaces, sometimes honeycombing the mushrooms.

A. (H.) matorus Folsom '33; Davis '35.

According to Davis, this species injures mushrooms in the caves at Leeds, Missouri.

A. (H.) manubrialis Tullb. and variety *assimilis* Krausbauer—Ripper '30; Stapel '32.

Very destructive to mushrooms in Austria. Ripper gives details of biology, ecology, etc. (Listed as a synonym of *A. armatum*.)

A. cyanocephalus Nic., *A. rufescens* Nic., and *A. purpurescens* Lubbock.

Reported as damaging mushrooms in England—Symes & Chorley '21.

Achorutes, species undetermined—Buller '09.

"Infested *Stropharia semiglobata* and some other species of *Agaracinae*, feeding on the spores; also on the fruiting bodies of *Polyporus squamosus*."

Onychiurus ambulans Nic.—Ripper '30.

Schöttella sp.—Gahm '29, '30b, d, '32a, '35; Thomas '31.

Lepidocyrtus cyaneus Tullb. and variety *cinereus* Fols.—Thomas '26, '29, '31, '34; Ripper '30; Gahm '32a, '35; Folsom '33; Davis '35.

Attacks mycelium and mushrooms. Sometimes very abundant.

L. lanuginosus (Gmel.)—Davis '35, '35a; Davis and Young '34, '35; Thomas '34; Davis & Claborn '35.

More destructive in Ohio and western Pennsylvania, where it occasionally causes much damage by honeycombing the mushrooms. Although found in eastern Pennsylvania, this large reddish species is seldom very injurious here.

L. albicans Reut.—Davis '35.

Heteromurus nitidus Templ. and *Tomocerus vulgaris* Tullb.—Ripper '30.

Proisotoma thermophila Axels.—Thomas '34.

Det. by J. W. Folsom. Injures spawn pieces and mycelium in Pa.

P. simplex Folsom—Davis '35.

"Attacking spawn, Capitol Heights, Md."

P. minuta Tullb.—Thomas '29; Ripper '30; Austin '33a; Davis '35.

“Damaging spawn, Arlington Farm, Va.”

Isotoma immersa Fols.—Folsom '28.

“In enormous numbers in a mushroom cellar in New York State, according to Lintner.”

Isotoma, species undetermined—Thomas '31; Gahm '32a, '35.

The species of *Isotoma* and *Proisotoma* sometimes destroy the mycelium in the newly planted spawn pieces.

Cyphoderus albinus Nic.—Ripper '30.

Entomobrya multifasciata (Tullb.)—Folsom '33.

“Eats fungus spores.”

Sinella höfti Schäf.—Folsom '33; Davis '35.

Davis reported commercial damage to mushrooms at Leeds, Mo.

S. caeca Schott.—Speyer '33.

Xenylla humicola (Fab.)—Folsom '33; Davis '35; Davis & Cla-born '35.

Folsom stated that this species was often injurious to mushrooms. Davis reported it from Kennett Square, Pa.

X. welchi Fols.—Folsom '16; Davis '35.

Attacks spawn and mushrooms, especially in the west.

X. mucronata Ax.—Speyer '33; Jary & Austin '37.

Sminthurus luteus Lubbock.—Walton '17.

“On field mushrooms in England.”

Hemiptera

Triphleps (Orius) insidiosus Say—Thomas '31.

Predacious on springtails. Only occasional in mushroom houses.

Dermaptera

Labia minor L.—Thomas.

Occasional in mushroom houses. Although it has been found in large numbers in the manure in mushroom beds on several occasions, it is not known to damage the mycelium or the mushrooms.

Orthoptera

Pristoceuthophilus pacificus Thom.—Camel Cricket—Popenoe '12, '17, '25.

Reported as eating into the caps of cultivated mushrooms on the Pacific coast.

Ceuthophilus uhleri Scudder—Cave Cricket—Haseman '33 correspondence.

“Does considerable damage to mushrooms in cellars.”

Crickets, undetermined species—Davis '35a.

Periplaneta americana L.—American Roach—Busek 1902.

This is usually not injurious to mushrooms.

Coleoptera

Hydrophilidæ

Cercyon hæmorrhoidalis Fab., *C. quisquilius* L. and *Sphæridium bipustulatum* Fab. are listed by Ripper '30 as being found in mushroom houses.

Staphylinidæ

Staphylinid beetles are found in mushroom houses in varying numbers, sometimes very abundantly. Usually they are feeding on springtails and other small animal life there, but there is some indication that some of the smaller species may occasionally cause injury by feeding on the growing mushrooms, eating out the interior of the smaller buttons. They may be secondary to other agencies which have started decay in the mushrooms.

Proteinus ovalis Steph.—Austin '33b.

“Possibly a predator; found in mushrooms attacked by other agencies, in England.”

Quedius fulgidus Fab.—Thomas.

One of the more common larger Staphylinids found in mushroom houses. Feeds on springtails, fly larvæ, etc.

Oxyporus femoralis Grav. and *O. major* Grav.—Thomas.

Collected inside *Pleurotus* sp. in woods, Kennett Square, Pa. Have not been found in mushroom houses.

Tachinus fimbriatus Grav.—In same *Pleurotus*—Thomas.

Trichophya pilicornis Gyll.—Mushroom Cave, Luray, Va.—

Reported by E. A. Chapin, U. S. National Museum.

Atheta arenicola Thoms.—Ripper '30.

A. virginica Brnh.—Davis '35.

"Extremely common in mushroom houses, Arlington Farm, Va., and throughout the mushroom growing district of Pennsylvania, Delaware, and New Jersey. Predacious, attacking the larvæ of the mushroom flies (*Sciara*) in the beds." The writer has also found this beetle feeding on *Tarsonemus* mites on mushroom beds at Kennett Square, Pa.

Philonthus sp.—Ripper '30.

Ptiliidae (Trichopterygidae)

Ptilium sp.—Davis '35.

"Reared from spawn from a house at West Chester, Pa." The writer has also found this minute beetle abundant in a mushroom house at Toughkenamon, Pa.

Ptenidium pusillatum Gyll.—F. C. Wood, Corresp.

"Pest in a mushroom house at Charlwood, Surrey, England." *Acratrichis* sp.—Ripper '30.

Nephanes sp.—Davis '35.

"Feeding on spawn, Kennett Square, Pa."

Histeridae

Hister bimaculatus L.—Thomas.

Occasional in mushroom houses. Not known to cause injury. *Acritus* sp.—Davis '35.

"Predacious on springtails and mites, Arlington Farm, Va."

Atholus duodecimstriatus Schr.—Ripper '30.

Saprinus lautus Er.—Calwer '16.

"In faulendem Agaricus."

Anthicidae

Tomoderus constrictus (Say)—Thomas '31.

Frequent in Pennsylvania mushroom houses, where it is predacious on springtails, etc.

Elateridae

Melanotus sp.—Thomas.

Larvæ of this genus have been found feeding in fungi in woodlands, and on two occasions the writer has found several boring up through mushroom stems in mushroom houses. These larvæ

were probably brought into the houses with the casing soil taken from sod lands, where they are normal inhabitants.

Dermestidæ

Dermestes cadaverinus Fab.—Strong '22.

Intercepted in California in dried mushrooms from China.

Cryptophagidæ

Cryptophagus distinguendus—Ripper '30.

Mycetophagidæ

Litargus sp.—Thomas '34; Davis '35.

Usually not common. Eats small holes in caps and stems. Davis states in 1936 correspondence that *L. balteatus* Lec. is the species found in mushroom beds at Arlington Farm, Virginia. The writer has found it injuring cultivated mushrooms at Hershey, Pa., and West Chester, Pa.

Lathridiidæ

Corticaria serrata Payk.—Davis '35.

“Common on and about beds at Arlington Farm, Va. May feed on spawn.”

Coccinellidæ

Halyzia sedecimguttata L., *Vibidia duodecimguttata* Poda, and *Thea vigintiduopunctata* L. (all Tribe Psylloborinii)—Strouhal '26.

“Feed on fungi injurious to plants, but are not very beneficial, and may help to spread these fungi.”

Scarabæidæ

Aphodius fimetarius L.—Ritzema-Bos '17; Ripper '30; Thomas '34.

Although occasionally found in mushroom caves in the United States, it is not a pest here. According to Ritzema-Bos, however, this species is a well known mushroom pest in France, feeding on both mycelium and mushrooms.

A. ater DeG.—Ritzema-Bos '17.

Oxyomus sylvestris Scop.—Ripper '30.

Geotrupes stercorosus Scriba (*sylvaticus* Panz.)—Zwölfer '35.

“Observed in 1934 attacking the stems and caps of young healthy edible mushrooms, *Boletus edulis* (Bull.) Fr. in South Germany. About ten per cent of these mushrooms were unfit for consumption.”

Lepidoptera

Noctuidæ

Metalestra quadrisignata Wkr.—Thomas '31.

This looper caterpillar enters the mushroom house with the casing soil, and sometimes eats large holes in the caps and stems. Fortunately it feeds only a short time, then pupates. It is not common in mushroom houses.

Pyralidiidæ

Pyralis farinalis L.—Davis '35.

Reared from mushroom beds, Arlington Farm, Virginia.

Bombycidæ

Diacrisia (*Spilosoma*) *congrua* Walk.—Beutenmüller 1890.

“Attacks mushrooms but is rare. Parkville and West Farm, N. Y.”

Tinæidæ

Tinea cloacella Haw.—Krause '16.

“Larvæ attacked dried mushrooms in Germany.”

Lepidopterous larvæ, not identified—Austin '33b; Strong '21.

Strong reported these larvæ infesting mushrooms in England.

Diptera

Chironomidæ

Forcipomyia cilipes Coq.—Thomas '34.

The larvæ of this fly are sometimes found in small scattered groups in the manure of the beds, feeding on the mycelium. Never common enough to be really injurious, however.

Mycetophilidæ

A number of species of the genus *Sciara* occur in mushroom houses, usually one or two species being represented in each house. Of these, some are quite rare. *Sciara multiseta* Felt,

S. coprophila Lint. and *Neosciara pauciseta* Felt are the most common and most injurious species in Pennsylvania. Their injury is to the spawn pieces, to the growing mycelium, and to the interior of the growing mushrooms, ruining the latter. They enter the houses with the manure, and are also attracted in by the odor of the growing mycelium.

Austin and Pitcher '36b have recently described the hypopygia and other characters differentiating the males of *S. agraria* Felt, *S. auripila* Winn., *S. vivida* Winn., *S. umbratica* Zett. and *S. fenestralis* Zett.

Sciara larvæ have a chitinous black head capsule, differentiating them from the larvæ of Phorid flies, which have no head capsule, but which cause similar injury to mushrooms. Several Sciariid species found in mushrooms outdoors have not yet been found injuring artificially grown mushrooms.

Sciara agraria Felt—Felt 1896 (original description); Popenoe '12, '17, '25; Theobald '27, '28a, '29; Thomas '31; Austin '33a; Austin & Jary '34, '35; A. & Pitcher '36b.

S. præcox Meig.—Symes & Chorley '21; Theobald '27, '28a; Ripper '30.

According to Theobald, and to Symes & Chorley, this is one of the worst mushroom pests in Britain.

S. auripila Winn.—Speyer '27, '33; Austin '33a; A. & Jary '34; A. & Pitcher '36b.

S. coprophila Lint.—Lintner '94 (orig. description); Falconer '97; Johannsen '12; Thomas '29, '31.

S. multiseta Felt—Felt '96 (orig. descr.); Smith '08; Johannsen '12; Popenoe '12, '17, '25; Thomas '31.

S. vivida Winn.—Austin '33a; A. & Jary '34; A. & Pitcher '36b.

S. umbratica Zett.—Austin '33b; A. & Jary '34; A. & Pitcher '36b.

S. varians Johns.—Austin and Jary '37 describe the male genitalia; Jary and Austin '37 say it is not known to infest mushrooms.

S. fenestralis Zett.—Austin '33b; A. & Jary '33, '34, '35; Jary '34; A. & Pitcher '36a, b; Pitcher '36.

This species and *S. umbratica* were bred from mushrooms and also fed on the mycelium in the beds. Austin and Jary '33 give

considerable information on the biology and control experiments, while Pitcher '36, gives extensive life history and biology notes and larval instar measurements. Austin and Pitcher '36a give a method for rearing this and other Sciarids.

S. annulata Meig.—Theobald '28b, '29.

According to Austin and Jary '34, and Austin '33b, this species is probably the same as *S. umbratica* Zett.

S. frigida Wtz. and *S. ingenua* Duf.—Cause mushroom injury in Austria, according to Ripper '30.

Neosciara pauciseta Felt—Johannsen '12; Stewart '27; Thomas '29, '31.

N. sexdentata Petty—Munro '37.

Abundant in a greenhouse mushroom bed at Fargo, North Dakota.

Sciara, species undetermined—Smith 1894, '09; Güssow & Odell '27; Charles & Popenoe '28; Gahm '30, '32a, '35; Plant. i. Danmark '32; Stapel '32; Jary '34; Thomas '34; Davis & Young '34, '35; Davis '35a; Davis & Claborn '35; McCarthy '36; McDaniel '32.

Leia sp., *Exechia* sp., and *Mycetophila* sp.—Weiss '21.

According to Weiss, the larvæ of the last two are frequent in wild mushrooms and occasional in cultivated mushrooms.

Fungivora fungorum DeG.—Okada '36b.

The larvæ infest *Armillaria mellea*, *Boletus elegans*, & *Pholiota* sp.

F. centralis Mats.—Okada '34.

The larvæ feed on mushrooms in Hokkaido.

Bolitophila disjuncta Lw.—Okada '35, '36a.

This species prefers *Armillaria mellea* (Vahl.) Fr. and sometimes *Hypholoma sublateritium* (Schaeff.) Fr.

B. maculipennis Wlk.—Okada '35.

This attacks *Pholiota nameko*.

Bolitophilella cinerea Mg.—Okada '35, '36a.

Prefers *Pholiota* species, but feeds on a wide range of fungi.

B. japonica Okada—Okada '35.

Attacks *Pholiota* and *Hypholoma* species. Most of these fungi are soft and sticky on the surface, and these insects seem to select them for their physical characters.

Cecidomyiidae

Mycophila (*Pezomyia*) *speyeri* Barnes—Barnes '26, '27, '28, '29; Speyer '26, '27; Austin '34; Austin & Jary '34; Anderson '36.

Barnes stated that the larvæ feed on mycelium. According to Anderson, Dr. Mathias Thomsen reared this species from larvæ found in decaying mushrooms at Gentofta, Denmark.

M. fungicola Felt—Felt '11a, b; Barnes '27; Anderson '36.

Reared from larvæ from young mushrooms collected in Cal. in '97.

Miastor sp.—Theobald '28a; Barnes '28; Ripper '30.

Taken from the gills of mushrooms and spawn in England. The larvæ are pædogenetic, giving rise to living young.

Cecidomyiid larvæ, unidentified—Austin '33b; Gahm '32a; Thomas '31.

Undetermined Cecid larvæ are occasionally found in immense numbers on the casing soil and on the mushrooms, where they mine the outside tissues, giving the mushroom a yellowish, slimy appearance. They also feed on the mycelium in the beds.

Lestodiplosis sp.—Felt '32, correspondence; Thomas '34.

According to Felt, these larvæ are predacious on mites.

Scatopsidae

Rhegmoclemma atrata Say—Thomas '34.

A few larvæ feeding on mycelium, Kennett Square, Pa., 1934. *Scatopse fuscipes* Meigen-infests *Armillaria matsutake* in Japan and Korea, according to Okada '38.

Phoridae

The small active Phorid flies are frequently very abundant in mushroom houses. The larvæ feed on the newly-planted spawn-pieces and on the mycelium. Later, during the warm weather of spring they render the interior of the pinheads and larger mushrooms spongy and unfit for market. The first four species in the following list are those usually found in Pennsylvania mushroom houses. They enter the houses with the manure, or through the doors and ventilators after the crop has started.

They are normal inhabitants of the composting mushroom piles outdoors. The flies have been found to carry the spores of several of the mushroom diseases.

Megaselida (*Aphiochæta*) *albidihalteris* Felt—Felt 1896, original description; Malloch '12; Popenoe '12, '17, '25; Ripper '30; Thomas '31; Plant. i. Danmark '33; Stapel '32; Austin '33a, '34; Austin & Jary '34; Jary '34; Davis '35a.

Bred from *Agaricus campestris* and from *Coprinus comatus*. This is the most common Phorid enemy of mushrooms in England.

M. iriquoiana Malloch—Davis '34; Davis & Young '34. Kennett Square, Pa.

M. agarici Lint.—Lintner 1894, orig. description; Falconer '97; Malloch '12; Thomas '31.

Bred from *Agaricus campestris*, *Coprinus comatus*, and *Agaricus subrufescens* Peck.

M. minuta Lint.—Lintner '94; Falconer '97; Duggar '04.

According to Lintner, Dr. L. O. Howard reported this injuring mushrooms at Colora, Md.

M. aletix Comstock—Thomas.

Reared from undetermined fungus, Kennett Square, Pa., Sept. '29. Det. by C. T. Greene.

M. smithii Brues—Malloch '12, orig. descript.

Bred from *Agaricus* sp. in New Jersey.

M. straminea Malloch—Malloch '12, orig. desc.

"Reared from fungi by Popenoe."

M. cayuga Malloch—Malloch '12.

Bred from *Lepiota procera* in Maryland.

M. scalaris Loew—Thomas.

Bred from *Lepiota* sp. in woods. Kennett Square, Pa. Det. Greene.

M. pygmaea Zett.—Davis '35, California; Thomas '31, Pa.

M. lutea Meig., *M. flava* Fall, *M. nigra* Meig., *M. pumila* Meig.

All noted in *Agaricus prunulus* Fries. in Europe by Schiner, 1864.

M. bovistæ Gimmerth—bred from *Lycoperdon bovista*—Schiner '64.

M. projecta Becker—In fungi, Europe—Malloch '12.

M. cinerella Lundb.—Plant. i. Danmark '33.

M. matsutakei Sasaki—Sasaki '35, orig. descr.

Attacks the edible *Armillaria matsudake*.

Platypezidæ

Platypeza minorata Banks—Thomas '29.

Sometimes very abundant and destructive to field *Agaricus* in southern Pennsylvania and northern Delaware, though I have never found them in mushroom houses. Det. by E. T. Cresson, Jr.

Borboridæ

Leptocera (Limosina) ferruginata Stenh.—Austin '33b, '34.

“Taken from composted manure piles and from established beds.”

L. heteroneura Hal.—Austin '37a.

Emerged in June from mushrooms infested with larvæ of Phorids and other Diptera.

Ortalidæ

Chrysomya demandata Fab.—Thomas.

In immense numbers in one mushroom house before the bearing season, occasionally in other houses, Kennett Square, Pa. Not known to be a mushroom pest. Det. by J. M. Aldrich, U. S. Nat. Mus.

Drosophilidæ

Drosophila larvæ are occasionally found in mushroom houses in warm weather, especially in the spring, but usually attack only decaying or injured mushrooms, especially those affected with *Mycogone* and similar diseases, which they may help to spread. Several undetermined drosophilid species have also been reared from wild *Agaricus* and other fungi in meadows and woods.

Leucophenga varia Wlk.—Thomas '29.

Leucophenga, sp. undetermined—Thomas '29.

These two *Leucophenga* species were reared from decaying mushrooms in house at end of bearing season.

Drosophila funebris F.—Austin '33, '34.

Anthomyiidae

Muscina assimilis Fall.—Keilin '17.

The larvæ are frequently found in decaying fungi, where they feed on such Dipterous larvæ as *Drosophila confusa*, *Fannia canalicularis* L. and *Aphiochæta rufipes* Mg.

*Hymenoptera**Braconidae: Alysiinæ*

Aspilota concolor Nees—Austin '33a, '34.

Emerged from the pupæ of Phorids, *Megaselia albidihalteris* Felt.

Phænocarpa psalliotæ sp. n.—Telenga '35.

Reared from Dipterous larvæ in mushrooms in Germany.

Proctotrupidae

Calliceras (Ceraphron) ampla Ashmead—Thomas '29, '31.

This is a parasite of Sciarids in Pennsylvania, but is apparently very local and not effective in control. Determined by A. B. Gahan.

Exallonyx ligatus Nees—Austin '33b.

"Found with *Sciara* larvæ, but not common. May be a predator."

Diapriidae

Synacra brachialis Nees—Austin '33a.

"Probably a parasite of Dipterous larvæ in mushroom houses."

VERTEBRATA

REPTILIA: Chelonia: Turtles

Cistudo carolina (L.)—Box Turtle.

This turtle has occasionally been found feeding on wild mushrooms and other fungi in meadows and woodlands.

MAMMALIA

Muridæ: Mice and Rats

Mus musculus L.—House Mouse.

Mus norvegicus Erx.—Norway or Gray Rat.

These two widespread rodents are frequently quite injurious

in mushroom houses, where they eat into the caps and dig up the beds, causing much annoyance to the growers.

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NOTE ON PARATHERESIA INTRODUCTION IN LOUISIANA

The note in *Journal of Economic Entomology*, XXXI, 632 (1938), is much changed from the manuscript that was sent in May 30, 1938. This was done without consulting the writer and led in one instance to a preposterous statement, inasmuch as referring the whole tribe Theresiini to the single genus *Theresia* is indefensible and not merely questionable. The manuscript read that the reference of *Paratheresia* spp. "to *Theresia* is ridiculous taxonomically and confusing economically. One might as well refer the whole tribe Theresiini to the one genus *Theresia!*"

The note was sent in particularly to draw the attention of economic entomologists to the lamentable blunder of confusing *P. signifera* with *P. claripalpis*, which caused a heavy financial loss through a great expenditure of funds over a period of years with absolutely no positive result. The special emphasis laid on this point in the manuscript was suppressed in the published note.

It seems that, under the present management of the above journal, a contributor has no voice of his own but must say what is put in his mouth by its editor. The legitimate functions of an editor, once he accepts a manuscript for publication, do not include any changes or omissions of grammatically correct wording. Too many editors fancy themselves responsible for what a contributor says and often, not knowing the subject, make him say ridiculous things.—CHARLES H. T. TOWNSEND.

A GENERIC REALLOCATION FOR MYRMOTERAS KUROIWÆ

BY WILLIAM STEEL CREIGHTON

COLLEGE OF THE CITY OF NEW YORK

In 1930 the writer published, in this JOURNAL, a monograph of the ant genus *Myrmoter*as. At that time I was unaware of the existence of a description of a Japanese species attributed to *Myrmoter*as. In 1912 Matsumura described and figured, in the *Supplement to the Thousand Insects of Japan*, an insect which he called *Myrmoter*as *kuroi*wæ. The material on which Matsumura based his new species had been taken on the island of Okinawa, one of the Riukiu Islands, which together form a scattered archipelago extending from northern Formosa to the island of Kyushu. This fact in itself led me to doubt that *kuroi*wæ could belong to the genus *Myrmoter*as since the genus is so strictly confined to the old world tropics. To date the recorded northern limit of the range of *Myrmoter*as is Los Banos, Philippine Islands which lies just north of Lat. 14°. The island of Okinawa lies just north of Lat. 26° and it seemed exceedingly unlikely that a representative of *Myrmoter*as would occur eleven hundred miles to the north in a south temperate area.

A search into the bibliographical references concerning *Myrmoter*as *kuroi*wæ brought to light three publications in which the name has been cited. The first of these appeared in 1908 when Matsumura published in *Kuroi*wa his *Provisional List of Hymenoptera of Loochoo*. In this list *kuroi*wæ is mentioned as a manuscript name with no attendant description. The original description of *kuroi*wæ, as has been noted above, appeared in the *Supplement to the Thousand Insects of Japan* which was, apparently, published in 1912. The third reference, which consists only of the citation of the two just listed, appeared in the *Insecta Matsumura*, which was published by the Entomological Museum of Hokkaido, Imp. Univ., Vol. 1, in 1926-27. As may be seen the only data of any value in determining the status of *kuroi*wæ is that contained in the 1912 publication. This probably

explains why the insect has escaped the attention of European and American myrmecologists. The great majority of the issue of the *Thousand Insects of Japan* was destroyed in the earthquake of 1923. It is said that only fifteen copies survived but regardless of whether this is true it is certain that the work is of extreme rarity. Through the courtesy of the American Museum of Natural History I have been enabled to examine their set of this valuable publication. The original description of *kuroiwæ* is entirely in Japanese. I did not take the trouble to have this translated because the figure given by Matsumura shows that the insect described as *Myrmoteras kuroiwæ* is actually an *Odontomachus*. To judge from the figure I suspect that what Matsumura had was the ubiquitous *O. hæmatoda* but, since there have been two forms of *O. monticola* (subsp. *formosæ* and *major*) described from southern Formosa, it is possible that *kuroiwæ* belongs to one of these.

It may be added that this disposes of the one remaining ant cited as new by Matsumura. His *Polyrhachis bispinosa*, given as a manuscript name in the 1908 list, was never described. Matsumura himself subsequently recognized this form as a synonym of *Dicamma rugosum* var. *anceps* Emery.

A NEW GALL MIDGE ON RHODODENDRON

BY E. P. FELT

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Specimens of a gall midge were received under date of August 18, 1938, from Doctor Clyde C. Hamilton of the N. J. Agricultural Experiment Station accompanied by the statement that they were reared from larvæ commonly infesting the young tips of *Rhododendron* in a nursery at Huntington Station, L. I. It was also stated that such injury had been brought to Doctor Hamilton's attention for the previous four or five years though he had not been able to obtain adults previously.

The earliest signs of infestation occur in small leaves two inches in length or less, the margins being inrolled in somewhat swollen pale greenish-yellow masses folded over the midrib. As the infestation ages, the more seriously affected portions of the leaves are marked with a brownish spottings which may extend and unite, and in the case of some of the partly developed leaves, result in a nearly complete browning of the leaf. Leaves not so seriously affected are partly expanded with indistinct pale greenish bulges over much of the surface or even irregular browned areas suggestive of a leaf spot. The pale whitish maggots, about a twentieth of an inch long, are found only in the younger tightly rolled leaves. This description of midge injury is based on material collected by the author at White Plains, N. Y., August 24th. Trouble of this character had come to our attention in earlier years though invariably it was after the affected foliage had been deserted by the maggots. Credit for rearing the insect is due to Doctor Hamilton. The species is evidently somewhat generally distributed in an area within fifty miles of New York City.

Injury by this species is limited to the new growth and according to observations by Doctor Hamilton it may appear in late May or early June and then on the second growth occurring in August. The gall midge appears to be new and is therefore described below.

***Giardomyia rhododendri* new species**

MALE.—Length 1.25 mm. Antennæ one-half longer than the body, thickly haired, light brown, the fifth segment with the basal enlargement globose, the distal enlargement with a length one-half greater than its diameter; the stems with a length two and one-half and three and one-half times their diameters respectively. Mesonotum pale brownish-yellow, scutellum and postscutellum yellowish, abdomen pale yellowish-brown. Wings hyaline, halteres pale yellowish, coxæ and base of femora pale straw, distal portion of femora, the tibiæ and tarsi a variable straw color, the simple claws strongly angulate. Genitalia; basal and distal clasp segments normal, the dorsal plate broadly and triangularly emarginate, the ventral plate lightly and roundly emarginate, the lobes slender and tapering.

FEMALE.—Length 1.25 mm. Antennæ about as long as the body, light brown, fourteen segments, the fifth cylindrical with a length two and one-half times its diameter, the stem with a length twice its diameter; the terminal segment narrowly oval and with a length two and one-half times its diameter. Palpi; first segment quadrate, second with a length three times its width, the third as long as the second and the fourth one-half longer than the third. Color nearly as in the male. Ovipositor short, the terminal lobes narrowly oval.

Type deposited in the U. S. National Museum.

This species runs in our Key, N. Y. State Museum Bulletin 231-232, page 118, near to *G. menthæ* Felt, the ventral plate characters serving to distinguish between the two.

SPEED OF CEPHENEMYIA

BY CHARLES H. T. TOWNSEND, PH.D.

The following brief explanatory data are offered on the speed, at 12,000 to 13,000-foot levels, of male deer botflies of the tentatively determined species *Cephenemyia pratti*, known only from New Mexico, Texas, Chihuahua and California, which speed has been challenged by Dr. Irving Langmuir in *Science* of March 11, 1938.

The challenger, judging fly metabolism and mechanics by man metabolism and mechanics and comparing the fly with a zeppelin (which, being lighter than air, has no bearing on the problem), not realizing that the fly's mechanism is vastly more efficient in doing work for itself than the man's, nor that it works on stored energy instead of constant food consumption, and assigning wrong values for the fly in a ballistics equation, came to the extraordinary conclusion that 25 m.p.h. is a fair estimate of *Cephenemyia* speed!

Since the editor of *Science* has twice declined to publish a reply to the challenge, it must be stated here that the latter embraced the following assertions: That the fly has a very flat head, so that $\frac{1}{4}$ is too low a value for f in the ballistics equation; that $\frac{1}{2}$ is a lower than actual value for d and 1 is the value for p (here substituted for Greek letter ρ) in same equation; that with these values the equation gives 100 grams of drag at 818 m.p.h.; that 8 lbs. per square inch is the wind pressure on the fly's head at same speed, probably enough to crush the fly; that power consumption at same speed would be 370 watts per second; that the fly is 1 cm. in length and $\frac{1}{2}$ cm. in diameter; that a whirling piece of solder of same dimensions becomes invisible at 64 m.p.h.; that impact of fly on collision at 800 m.p.h. would be 310 lbs.; that fly must consume $1\frac{1}{2}$ times its own weight of food per second to maintain speed of 818 m.p.h. Now for the facts in the case.

In properly conceived flight position, the fly is streamlined to the limit, its movable head inclined slightly downward and its extended legs lying close beneath the abdomen. In this position it shows a total length of fully 16 mm. and a diameter of $5\frac{1}{3}$ mm. at nearly

$\frac{1}{3}$ the length, more than the posterior $\frac{2}{3}$ tapering to the leg tips. Its weight is about $\frac{1}{5}$ of a gram.

In the equation, $R = pd^2v^2f$ (R is drag; p , atmospheric pressure or air density; d , diameter; v , velocity; f , shape in relation to velocity), it should take $1/60$ as value of f , $1/7$ as value of d^2 , 490,000 to 657,700 as value of v^2 at 700 to 800 m.p.h., $7/11$ as value of p at the high levels where it attains top speed. It is to be noted that the complete streamlining of the fly reduces drag 50 per cent on both d^2 and f , making d^2 $1/7$ and f $1/60$; otherwise d^2 would be $2/7$ and f $1/30$. Power required at 800 m.p.h. is 1.95 times that required at 700 m.p.h.

On these values, the fly's drag at 800 m.p.h. would be 0.997 grams, requiring scarcely 3.63 watts power per second. But it now seems probable, in the light of aeronautic experiments during the past decade, that the fly does not much exceed the speed of sound. The writer's original announcement, made 12 years ago (*Scientific Monthly* of April, 1926), closed with the admitted possibility that the actual speed might be only $\frac{1}{2}$ the estimated. This is not an effort to hedge, for it was stated plainly at the time and was made in view of the inevitable exigencies of the most careful estimates. The actual speed must be determined by a high-speed camera taking 1,000 to 4,000 exposures per second. It will certainly fall between 409 and 818 m.p.h.

On the same values, at 700 m.p.h., we have for the equation: $R = 7/11 \times 1/7 \times 490000/1 \times 1/60 = 742.42$ dynes or 0.74242 gram drag. As we figure 1 watt power for 10,000 cm. gms. of drag per second or 3.13 watts for 31,300 cm. gms. per second at 700 m.p.h. less 20 per cent reduction of power to match the 20 per cent reduced drag due to weight at high velocity, the result of which drag reduction is embraced in the equation, we have 2.504 watts required per gram of drag or 1.859 watts for 0.74242 gram of drag, which is $1/402$ h-p. Thus 402 flies deliver 1 h-p. per second at 700 m.p.h. This is checked by the computation that 402 flies overcome a total resistance of 298 grams at the velocity of 31,300 cm. per second, which is slightly over 1 h-p.

While the above figures are the most accurate that can be computed with our present knowledge of insect metabolism and mechanics, they must be verified by future research on this prac-

tically unknown subject. As an example, a flea can jump over 200 times its height and live 18 months without food or water. What is known regarding the mechanics of the flea and its astonishing metabolism? When a man can jump twice as high as the Washington Monument and live a year and a half without a bite or a drink, it will be time to judge insect metabolism and mechanics by man metabolism and mechanics. The exoskeletal mechanics and cold-blooded metabolism of the insect with its stored energy, open blood system and extensively ramifying respiratory-air sac system are strongly contrasted with the endoskeletal mechanics and warm-blooded metabolism of man with his continual food consumption, closed blood system and pulmonary respiration, greatly to the advantage of the insect for doing work.

The fly takes no food and its power supply constitutes its marvelous mechanical secret deserving the most thorough investigation in the interests of aviation. Outside of oxygen assimilated in respiration, its entire power supply lies in its fatbody and was acquired during its maggot stages. Wimperis stated last year in his presidential address before the Royal Aeronautical Society that if we can suppress everything but laminar drag or if some entirely new motor is invented of much greater power per pound of weight, it may be possible to attain higher speeds than about 600 m.p.h. *Cephenemyia* has the second of these alternative requirements; namely, motor of far greater power per unit of weight!

The fly is of course totally invisible at top speed and leaves a visible blur in the air only when it suddenly decelerates to veer off and thus avoid collision with the observer. It requires very superior eyesight to sense the blur, which however becomes a disappearing dot against the sky in a straightaway course. A whirling object can not apply at all in this case. The fly probably decelerates to 100 m.p.h. at the blurred section of its course. The fact that the oncoming fly appears suddenly without previous sound warning implies a speed approximating that of sound. The writer stated in 1928 (*West Coast Leader* of March 27) that the fly is audible on approach, but he mistook the close-up sound for the sound of approach.

The fly never collides with any object, due to its power of super-rapid deceleration, which implies the same rate of acceleration on passing the object. If it should collide, its decelerated speed would result in very low impact. But a direct hit at 800 m.p.h. would develop an impact of only 10.09 lbs., since the fly would come to rest in 1.6 cm. distance, which gives 19.5 fly-impact units per ft. lb. At 700 m.p.h., direct hit impact would be 8.829 lbs. In any case the fly would decelerate to a fraction of the above impacts. It is evident that the fly has developed its extraordinarily rapid deceleration of necessity, as protection against collisions at its great speed. Less rapidity of deceleration would result in collision and the death of the fly. In millions of flight years the fly has perfected both its streamlining and its flight mechanics.

Dr. Langmuir's allusion to his recollections of deerflies shows that he confused the common bloodsucking tabanid fly *Chrysops*, called deerfly in the eastern United States, with *Cephenemyia*. He can scarcely have known the eastern *Cephenemyia phobifer*, which is rarely met with. *Chrysops* goes 25 m.p.h. but *Cephenemyia* goes more than 25 times 25 m.p.h.!

In conclusion, *Cephenemyia* can scarcely fail to reach 650 to 750 m.p.h. at top speed, which is by far the swiftest observed flight of all organisms and may with entire confidence be entered as a world record. The writer does not yet regard 800 m.p.h. as impossible but merely as improbable. Both the scientific and the lay press may therefore take note that *Cephenemyia* is not debunked by Dr. Langmuir's conscientiously advanced but grossly inaccurate data. It is the present speed champion of the world. Only its close ally, *Portschinskia* of Asia, may possibly compete with it. But the airplane should eventually excel both in speed.¹

¹ A detailed treatment of the mechanics of this subject will appear in Part XII of the *Manual of Myiology*, comparing the fly and the flea with both man and each other and the fly with both projectiles and airplanes.

AN ANALYSIS OF INSECT GROWTH CURVES*

BY LAURENCE C. WOODRUFF

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The purpose of this paper is not to contribute new material on statistical analysis but rather to point out the many valuable and helpful features of the ratio or logarithmic chart as a means of depicting growth in insects. This device either is unknown to the majority of entomologists or is not well enough understood to be accepted and used by those who have occasion to discuss growth curves. Since, as I will attempt to show, the ratio chart gives the only true and accurate conception of growth, it is most unfortunate that this type of illustration has not been more fully appreciated.

Unorganized masses of figures tell us little or nothing. The same facts tabulated in an orderly manner may reveal pertinent information, if we have the patience to analyze columns of figures. But when these data are arranged in the form of a chart or graph which can be deciphered almost at a glance, the evidence is quickly conveyed to the reader. Burdensome details are relegated to the background and the salient features are shown vividly through the use of points, lines, or surfaces. The principal use of graphs in biological work is to present large groups or series of figures in such a way that they will be intelligible in their entirety and so arranged as to give the clearest conception with no possible mistake as to their explicit meaning. Graphic devices often serve to popularize the results of an investigation and to force the information to the attention of the casual reader who otherwise might not take the necessary time to read the entire article.

During the past few years there has been a great increase in the appreciation and application of statistical charts in entomological literature and as a consequence we are faced with the problem of stabilizing our methods in order to avoid misinterpretation of the information presented and to make such information

*Contribution from the Department of Entomology, University of Kansas.

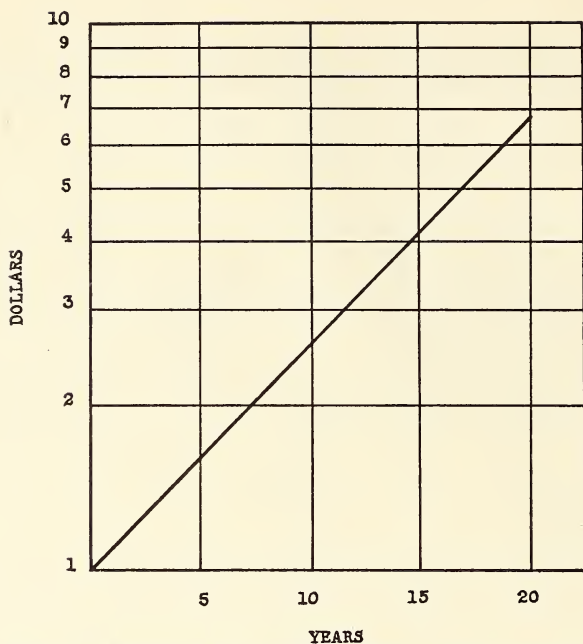


FIG. 1. Growth of \$1 at 10% interest. Ratio method.

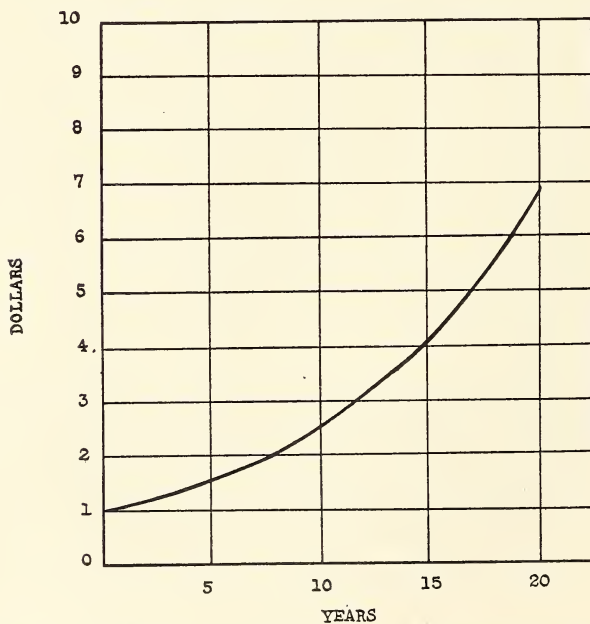


FIG. 2. Growth of \$1 at 10% interest. Difference method.

comparable with that of contemporary colleagues. The old question of the responsibility of a writer in analyzing his data comes to the foreground repeatedly. Surely, no one is better fitted to give a correct commentary than the investigator who has planned and executed the problem. But many times the facts speak for themselves in no uncertain terms when correctly portrayed in the form of a graph and no review is necessary. Care and thought in planning graphs are especially important since many readers have neither the critical ability nor the background necessary to protect themselves from misinterpretation. A statistical method or formula may become a dangerous weapon when applied to prove a pet thesis. Even without a deliberate intention an author often gives the wrong impression or distorts the true relation between cause and effect through the use of a faulty diagram. Great caution should be exercised in the selection of the type of chart to be employed, basing the choice upon a knowledge of the principles involved and at the same time keeping in mind the specific features of the problem at hand.

What, then, shall be the purpose of a growth curve for insects and how shall we go about picturing it in the most accurate and unmistakable manner? It depends entirely upon the emphasis; whether it shall be one of ratio or of amount of variation. Most of such information in entomological literature, or as a matter of fact in that of all biology, has been shown by simple line curves involving the charting of equal spaces for equal quantities and where weights, lengths, or other measurable units are plotted against time. This is known as the difference or absolute magnitude chart. In so far as a study or comparison of actual numerical data is concerned such a graph serves admirably, but it fails in the one purpose for which it is being used—that of showing the growth rate. For in the analysis of insect growth, while we are interested in the absolute magnitude, the relation or ratio of that magnitude either to itself or to other magnitudes is the all-important consideration. In short, we are concerned more with the proportionate than with the actual increase. We need then a diagram not of quantities as in the difference charts, but of ratios where isometric vertical distances do not represent equal absolute increments but equal proportional increments, that is,

equal rates of increase. Nothing meets these requirements quite so well as does the ratio chart.

The principle governing the ratio chart is the presentation of numerical data in relative magnitudes, not in absolute magnitudes. The avowed purpose then is that of exhibiting and comparing ratios. This type of chart is laid out upon coordinate paper so that the vertical lines represent absolute values while the horizontal lines represent logarithmic variances, where equal spaces mean equal magnitudes of change since the difference between the logarithms of two numbers is the ratio between these two numbers. This effect may be achieved in two ways: first, by converting the observed values into logarithms which may then be plotted upon equidistant spaces on the graph or, second, by employing especially prepared paper (see Fig. 3) on which the logarithmic ordinates are laid off on the vertical axis, using the logarithms of 1 to 10, and are numbered with the appropriate power of 10. This type of paper is very convenient in plotting growth curves and may be purchased from several supply houses in the simple form or in two and three cycles. Many persons shy at the mention of logarithms but they need have no apprehension since this "semi-logarithmic" graph paper can be used safely with no knowledge of logarithms in as much as the rulings are labelled with absolute values and curves may be plotted directly. The rapid decrease in the absolute differences between the logarithmic rulings at once engages attention but when this principle is applied in constructing the ordinate scale, equal vertical spaces anywhere on the diagram represent equal ratios of difference. Note in Figure 3 that the distance from level one to level two is the same as from two to four or from four to eight, all three being equal proportionate increases. Thus uniformity in the percentile rate of growth or increase is pictured on the ratio chart as a straight line. If the curve bends upward the rate is increasing and if it bends downward the rate is decreasing. Comparative gradients of separate parts of the same curve or of different curves indicate equal rates of increase or decrease, since a given per cent of increase is always represented by the same vertical distance upon the diagram regardless of the absolute magnitude.

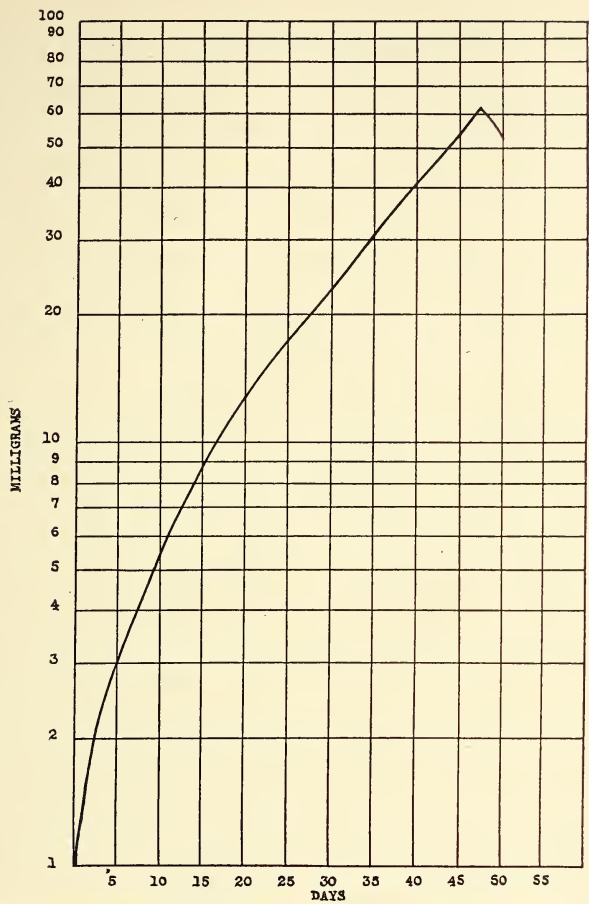


FIG. 3. Growth curve for *Blattella germanica* (somewhat idealized). Ratio method.

As has been mentioned frequently in this article, the principal argument for the use of the ratio type of chart in picturing growth curves of insects rather than one based on absolute values is the fact that the controlling interest is in the rate of increase or decrease which is not shown on the difference chart. Why then should an author employ a device which fails in the very purpose for which it was chosen? The slope of the curve in the difference chart has no meaning other than that of indicating the

trend in the change of absolute magnitude while to a reader accustomed to interpreting ratio diagrams "the slope of the line tells the story," and that story can be read at a glance. Furthermore, while the ratio chart primarily expresses rates of increase or decrease, the absolute values may be read directly from the chart, thus making this type of diagram available for both purposes. The best that can be said of the difference chart is that it shows any change in value and usually indicates the grosser rate but, uniformity is represented by an exponential curve which cannot be read accurately at sight and must be interpreted from its relation to the base. Such mental operations are difficult and often the results are misleading or confusing.

The advantages of the ratio chart over the difference chart are many. In the comparison of two curves plotted upon ratio charts, it is the slopes that are comparable and not the points above the base line. Hence, we may move either curve bodily, until the two approximate each other, merely by reducing all numbers by a common divisor. The distance above the base line has no significance as it has in the difference chart and thus growth curves for animals with widely different masses may be safely and accurately compared on the same diagram, an operation rarely possible by other methods. Sometimes, factors and relationships in the problem of insect growth which have escaped observation by the investigator are revealed through the use of ratio charts. One great expediency is in forecasting. Where the changes in rate of growth are evident from the slope of the curve, future developments may be anticipated by extrapolation with a better than fair degree of accuracy.

The ratio chart is not without inconveniences. One common criticism is that it cannot be read easily. But this applies only to the beginner, who because of being accustomed to other types of charts may have some difficulty in orienting himself to the direct course of the ratio curve. When the logarithmic rulings are marked with their absolute values, the graduated ordinates soon become as familiar as in any other type of chart. Another and somewhat more serious disadvantage is the fact that there is no base line, which means that it is impossible to plot values below the lowest power of 10 selected or to compare positive and

negative quantities. As a general rule, however, this is not necessary in charting growth curves for insects.

The classical example of the fallacious impression which may be obtained of growth curves shown by the difference method is

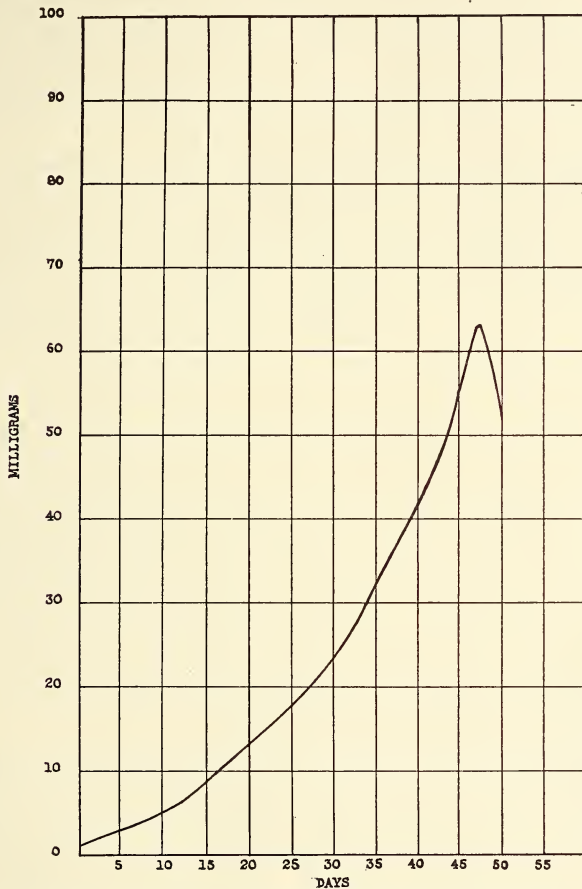


FIG. 4. Growth curve for *Blattella germanica* (somewhat idealized). Difference method.

the plotting of interest rates. In Figures 1 and 2 the growth of \$1.00 at 10%, compounded annually, has been charted by the two methods so that they may be contrasted. Common sense tells one that the ratio is constant throughout the entire period and

this is shown most forcibly in Figure 1 where the growth is represented by a straight line, indicating uniformity in the rate. Figure 2 shows identically the same data but with the curve plotted by the arithmetic difference method. Here we are plotting differences in the annual accumulations but the average reader would naturally enough be misled to infer falsely that the rate increases progressively, since this is indicated by the slope of the line. In this chart the growth is represented by an exponential curve and the uniform rate is lost to the eye.

In entomological literature one finds that this same mistake has been made repeatedly in connection with the growth rate of insects. In Figures 3 and 4 I have plotted the growth of a roach (*Blattella germanica*) as a working example. Note that in Figure 3 where the actual progress is shown by the ratio method, the rate of increase is most rapid during early life and that this diminishes slightly with time, the decline of the curve to the right indicating a decreasing rate. The type of curve plotting used in Figure 4 is actually not intended to show the rate of growth but has been so interpreted by many authors who because of such an assumption are led to speak of the growth as slow during the initial period but gradually increasing and becoming most rapid during the later periods of the insect's development. It is the levels of points on this type of curve which are significant and not the slope. Yet the characteristic of a curve which usually attracts the interest of the observer is its comparative direction and the points are examined only when a deep interest in the problem stimulates detailed study.

Since this situation prevails in the present use of the difference chart for showing growth curves of insects and since such charts for distinct insects are not truly comparable, it seems that for the sake of accuracy it is high time that the ratio chart finds its place in entomological research. One thing is certain—that greater uniformity in methods of presenting growth curves by the various workers is essential in order to render similar data comparable either at the same time or at successive periods.

SUMMARY

Difference charts in which the absolute values are used in plotting growth curves of insects are unsatisfactory since the line

of the curve has no significance when interpretations of rate are desired, showing only the changes in magnitude. On the other hand, the ratio chart, whose basic concept is that of relative rather than absolute change, indicates the true rate of growth through the comparative changes in the curvature of the line. The features of a curve which attract the greatest attention are concerned with direction or slope. These features, therefore, should not be misleading as they are in the difference chart but a true representation of the course of growth. In the ratio chart, increases or decreases are shown proportionately by a curve which denotes the trend of the growth rate accurately and clearly, uniformity being designated by a straight line. Arithmetic values may be assigned to the logarithmic ordinates so that changes in absolute magnitude can be easily interpreted and thus a dual purpose chart is obtained.

BOOK NOTICE

Biological Survey of the Mount Desert Region. Part VI, The Insect Fauna. By William Procter, D.Sc. Published by The Wistar Institute of Anatomy and Biology, Philadelphia, 1938. 496 p., 1 port., 1 fold. map, 11 illus.

This dignified and well printed book is a check list of the insects collected on the Island of Mount Desert, Maine, and is Part VI of the Biological Survey of the Mount Desert Region, founded and directed by the author of the present volume. Records are given of species collected during the past twenty years, and exclusive of the mites and spiders, there are 5,352 species listed in 2,203 genera and 297 families. This rich insect fauna flourishes amid a diversified flora embracing plants typical of the arctic region, of the Canadian zone and of the southern coastal plain. According to the author, Mount Desert in places is almost undisturbed ecologically, but he fears that this condition will not continue, owing to the gipsy moth and to activities in "improving" the woods. Doctor Procter's list is plentifully interspersed with notes on food plants, and on where to look for many of the species, and I am glad to note that the months of the year have not been reduced to Roman numerals. These characteristics increase readability and interest and give life to the list.

The Lepidoptera are represented by 1,374 species, the Diptera by 1,370, the Hymenoptera by 1,008, and the Coleoptera by 888. In the sixteen remaining orders the total number of species is 712, but additional collecting is bound to increase this.

Entomologists interested in geographical distribution will find this list useful and authentic and a welcome contribution to our slowly growing fund of knowledge about the insect faunas of particular regions. I personally appreciate the appearance of this list because it has revived my interest in the types of insect food habits prevalent in certain areas, and I expect to utilize the list in a study of such types on Mount Desert Island.

Doctor Procter's book is dedicated to the memory of Charles W. Johnson, who is still remembered with appreciation and fondness by many entomologists.—H. B. WEISS.

A REVIEW OF THE MUSCOID GENUS EUMACRO-
NYCHIA WITH KEY AND DESCRIPTIONS
OF NEW SPECIES (DIPTERA)¹

BY H. J. REINHARD

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The genus *Eumacronychia* was established in 1892 by Townsend (Trans. Am. Ent. Soc., 19: 98) and included two species described as new, viz., *decens* and *elita*, of which the first mentioned was designated as the genotype. Coquillett in his well known "Revision of North American Tachinidæ" considered the genus a synonym of *Hilarella*, with which Aldrich concurred (Catalogue, p. 476). In 1926 Allen (Proc. U. S. N. M., 68: 84-94) concluded that the genus was valid and published descriptions of five new species with a key to distinguish the known forms.

Little is known concerning the biology or host relationships of the species belonging to *Eumacronychia*. In distribution the genus is restricted largely to the Southwest. The flies appear more commonly active during July and August and most of my specimens were collected while feeding at nectaries on pods of cowpeas. A few were swept from the ground on barren sandy areas where they alighted exposed to the hot sun.

The species are strikingly similar in general appearance, but the male genitalia in most cases show good specific characters for distinguishing the various forms. The females are more difficult to identify specifically on structural characters and have been placed mainly by association with the opposite sex in the field. A recent study of my material, based principally upon male genitalia, has disclosed a number of undescribed species. It appears desirable to publish these with a key to the present known forms. Types of all new species are in my collection.

Members of this genus are small to medium-sized species (4 to 9.5 mm.) in which the abdomen is characteristically marked by alternating white and black cross bands. As a group the present

¹ Contribution No. 431 from the Division of Entomology, Texas Agricultural Experiment Station.

known species show, among others, the following characters: Front at least moderately wide and orbital bristles (two proclinate, one reclinate) present in both sexes; ocellars well developed, proclinate; frontal bristles in a single row, stopping at or but slightly beneath base of antennæ; verticals two pairs; frontal stripe reddish yellow, wider than one parafrontal on upper half and usually pollinose; antennæ reaching far below middle of face; arista bare, middle segment short; facial depression wide and moderately deep, ridges bare except a few bristly hairs next to vibrissæ; sides of face not narrowed downward, bare to distinctly hairy; vibrissæ well developed, decussate, situated slightly above front edge of oral margin; cheek clothed with only fine hairs on lower border; proboscis much shorter than height of head, labella fleshy; palpi well developed, usually yellow; eyes bare; back of head densely pollinose, beset with only black hairs. Thorax with well differentiated dorsocentral bristles, two in front and three behind suture; acrostichals hair-like or absent; sternopleurals two; pteropleural small; propleura and prosternum bare; calypters opaque, white; postscutellum not developed; scutellum black with well developed marginal bristles. Abdomen never with discals; genitalia in male large and prominent, in female the first genital segment rather broadly exposed, effecting the appearance of a fifth abdominal within which the second genital segment is retracted and shows a slitlike genital opening. Legs black, bearing moderate-sized bristles; hind tibiæ not ciliate; claws and pulvilli usually longer in male but sometimes short in both sexes; middle tibiæ with one bristle on outer front side near middle; fore tarsal segments ordinary in structure and not ornamented. Wings normal in shape; veins bare except third which is setulose halfway to small cross vein; first posterior cell open far before extreme wing tip; hind cross vein oblique to fourth, which it joins about one-third the distance from bend to small cross vein; last section of fifth vein never exceeding one-half the length of preceding section; costal spine small or vestigial.

To avoid a profitless repetition of all characters common to the members of the genus, only the more essential items or distinguishing differences are mentioned under the descriptions. The following key will assist in separating the thirteen known species.

KEY TO SPECIES OF EUMACRONYCHIA

1. Fourth abdominal segment entirely black 2
 Fourth abdominal segment red, at least on apex 6
2. Parafacials with distinct black hairs extending on upper half 3
 Parafacials without black hairs or at most with a few minute ones
 on lower extremity 5
3. Scutellum with two pairs of large marginal bristles 4
 Scutellum with three pairs of marginals; palpi distinctly enlarged;
 abdomen not elongate; claws and pulvilli short; male only (Calif-
 ornia) *crassipalpis* n. sp.
4. Abdominal segments 2 and 3 with defined pollinose cross bands on basal
 two-thirds (Colorado, Washington) *rohweri* Allen
 Abdominal segments 2 and 3 with dense pollen extending to hind
 margin of each (Manitoba) *elongata* Allen
5. First abdominal segment without median marginals; antennæ reddish
 yellow; claws and pulvilli short in both sexes (Texas) *alternata* n. sp.
 First abdominal segment bearing median marginals; third antennal
 segment infuscated; claws and pulvilli elongate in male (New Mexico,
 California) *elita* Townsend
6. Parafacials clothed with black hairs on upper half 7
 Parafacials bare or with only pale hairs on upper half 8
7. Parafrontals beset with long erect bristly hairs; inner forceps of male
 genitalia curved abruptly forward at tip; frontal stripe in female with
 sides parallel from antennæ to vertex (Ohio) *nigricornis* Allen
 Parafrontals practically bare; inner forceps of male tapering evenly to
 tip as viewed from side; frontal stripe in female gradually widening
 toward vertex (Texas) *tricosa* n. sp.
8. Front not narrowed toward antennæ 9
 Front distinctly narrowed at antennal base 10
9. Small species rarely exceeding 5 mm.; male with minute claws and
 pulvilli; outer genital forceps in profile much wider than inner ones
 and with the anterior apical extremity broadly rounded (Texas).
 *agnella* n. sp.
 Larger species (average 7 mm.); male with elongate claws and pulvilli;
 outer genital forceps hardly exceeding width of inner pair and with
 the anterior apical extremity prolonged and angulate (Texas, New
 Mexico, California, Central America) *sternalis* Allen
10. Arista thickened on basal three-fifths 11
 Arista thickened on basal two-fifths; in male, lobes of fifth sternite
 prominent with an acute incurved marginal projection near middle;
 inner forceps not bowed as viewed from behind, outer pair slender or
 fingerlike; in female, first genital segment rounded above; cheek two-
 fifths eye height (Texas) *prolixa* n. sp.
11. Males 12
 Females 14

12. Cheek at most one-third eye height; inner forceps divided but only slightly divergent beyond middle13
 Cheek nearly one-half eye height; inner forceps bowed and widely separated at middle as viewed from behind; penis geniculate, the apical segment flattened or straplike; lobes of fifth sternite prominent with the inner margin evenly rounded (New Mexico, California).
decens Townsend
13. Outer forceps in profile broadly bowed and tapering sharply to middle, thence gradually narrowed to a pointed tip (New Mexico, Arizona, Utah)*montana* Allen
 Outer forceps not bowed, but rather distinctly twisted on long axis, terminating in a flattened spatulate tip (Texas, New Mexico, Arizona).
tortilis n. sp.
14. First genital segment evenly rounded above15
 First genital segment laterally compressed and ridged along median line above*tortilis* n. sp.
15. Larger species 6 to 8 mm. in length; cinereous or pale gray in general aspect; apical scutellars and median marginals on second abdominal segment usually present*decens* Townsend
 Smaller (one specimen, 5 mm. in length); plumbeous or dark gray in general appearance; apical scutellars and median marginals on second abdominal segment absent*montana* Allen

***Eumacronychia crassipalpis* new species**

MALE.—Front on anterior extremity equal eye width and hardly any wider at vertex; parafrontals moderately clothed with short black hairs, which extend downward over entire surface of parafacials; facial depression only a little longer than its maximum width; antennæ reaching to lowest fifth of face, third segment black and rather noticeably inflated or thickened, about two and one-half times longer than second; arista black, thickened on proximal two-fifths; cheek one-third eye height; palpi brownish, unusually thickened on apical two-thirds; vibrissal axis of head a trifle shorter than antennal. Scutellum bearing three pairs of marginal bristles, the apical pair slightly divergent and fully one-half as long as the preceding pair. Abdomen rather short and compact, black, pollen bands on segments two and three extending on venter; first segment bearing one pair of median marginal bristles which are almost as strong as the pair on segment two; third and fourth segments each with a marginal row; genitalia shining black, in repose moderately extruding from tip of abdomen; first genital segment bearing a marginal row of horizontal bristly hairs; fifth sternite not prominently exposed, lobes beset with longish backwardly directed hairs. Legs black, moderately stout, not villous; claws and pulvilli much shorter than apical tarsal segment. Wings gray hyaline; costal spine small but distinct.

Length: 6 mm. Female, not known.

Holotype: California (without precise locality), September, 1931, no collector's label.

The compact build, thickened palpi and antennæ at once distinguish the species from other members of the genus.

***Eumacronychia alternata* new species**

MALE.—Front at base of antennæ narrower than width of eye; parafrontals, parafacials and cheeks with dense silvery gray pollen, the former practically bare but a few scattered short black hairs present on upper part; antennæ wholly reddish yellow, third segment slender and nearly three times length of second; arista brownish, shorter than antennæ, thickened on basal three-fifths; parafacial bare or at most with inconspicuous delicate pale hairs; cheek one-fifth to one-fourth the eye height; palpi yellow, slender but somewhat thickened at tip; proboscis stout, apical segment only a trifle longer than palpi; vibrissal axis of head distinctly shorter than the antennal. Scutellum with two large pairs of marginal bristles, apical pair absent. Abdomen black, slightly elongate and gradually tapering apically; pollen bands on intermediate segments extending narrowly on venter; first segment without median marginal bristles, second with one pair; third and fourth segments bearing the usual marginal row; genitalia black, large and prominently extruded from tip of abdomen; inner forceps terminating in a blunt tip, divided on apical half but not divergent, clothed behind with fine reclinate hairs; first genital segment bare, slightly pruinose; lobes of fifth sternite inconspicuous. Legs black; hind femur with some longish fine hairs along lower edge; claws and pulvilli shorter than apical tarsal segment. Wings sub-hyaline; costal spine vestigial.

FEMALE.—One specimen taken in company with the males described above is provisionally referred here. It differs as follows: Front at base of antennæ distinctly exceeding the eye width; vibrissal axis of head more nearly approaching length of antennal axis; third segment of antennæ thicker and hardly more than twice the length of second; arista thickened barely to middle; pollen bands on abdomen extending broadly on venter; hind femur not villous.

Length: 5 to 7 mm.

Holotype: Male, College Station, Texas, July 9, 1917 (H. J. Reinhard). Paratypes, one male and one female, same data as holotype.

***Eumacronychia elita* Townsend**

Eumacronychia elita Townsend, Trans. Am. Ent. Soc., Vol. 19, p. 100, 1892; Allen, Proc. U. S. N. M., Vol. 68, p. 91, 1926.

A small species very similar to the preceding from which it differs principally in having elongated claws and pulvilli; first abdominal segment with a pair of median marginal bristles; third antennal segment blackish and the first genital segment beset with a row of small but distinct bristles near middle above.

Two males and one female labelled "So. Calif., April 5, 1931," no collector's label.

The female sex has not been positively identified. The specimen here included was presumably taken in company with the males mentioned above. It agrees in most details with the characters listed under *alternata*.

Holotype in the U. S. National Museum. Type Locality: Las Cruces, New Mexico.

Eumacronychia rohweri Allen

Eumacronychia rohweri Allen, Proc. U. S. N. M., Vol. 68, p. 92, 1926.

Allen's description, which is readily accessible, provides most of the essential details. A few additional items with reference to the structure of the genitalia may be added here. Inner forceps elongate, almost straight and very thin in profile, viewed from the rear tapering to a pointed tip, divided beyond middle but not at all separated; outer forceps wider and almost as long as inner ones; claspers rather short and blunt-tipped; penis bowed forward near middle and somewhat swollen or flask-shaped near apex; first genital segment shining black, bearing bristly hairs on apical half above. The female sex is not known.

Six males as follows: two, Bull Prairie, Lake Co., Oregon, July 22 and 23, 1932, 7000 feet (D. K. Frewing); three, Signal Peak, Washington, June 21, 1935, 5111 feet (J. Wilcox); and one, Drakes Peak, Lake Co., Oregon, 8300 feet (D. K. Frewing).

Holotype in the U. S. National Museum. Type Locality: Florissant, Colorado.

Eumacronychia elongata Allen

Eumacronychia elongata Allen, Proc. U. S. N. M., Vol. 68, p. 93, 1926.

I have not seen any specimens of this species. It is so far the only known member of the genus in which the abdominal segments are densely pollinose to the apices. This outstanding character should make it readily recognizable. The female is not known.

Holotype in the Canadian National Collection. Type Locality: Onah, Manitoba, Canada.

Eumacronychia nigricornis Allen

Eumacronychia nigricornis Allen, Proc. U. S. N. M., Vol. 68, p. 90, 1926.

The type series (one male and one female), which I have not seen, represents the only known specimens. As described, the species differs from all related forms in having the parafrontals and parafacials clothed with long, erect, black, bristly hairs.

Holotype (male) and allotype (female) in the Ohio State Museum (J. S. Hine Collection). Type Locality: Sugar Grove, Ohio.

Eumacronychia tricola new species

MALE.—Front at base of antennæ about three-fourths, and at vertex equal to width of eye; parafrontals grayish yellow, bearing a few scattered short black hairs; antennæ extending to lowest fifth of face, proximal segments reddish yellow, third infuscated, slender and about three times longer than second; arista black, thickened to middle; parafacial white pollinose on yellow ground color, sparsely clothed on entire surface with short but distinct black hairs; palpi yellow, a little thickened apically; vibrissæ stout, decussate, situated slightly above front edge of oral margin; cheek one-fifth to one-fourth eye height; vibrissal axis of head barely two-thirds length of antennal axis. Marginal scutellar bristles two pairs, large, apical ones reduced to small decussate hairs. Abdomen rather slender or pointed apically, black except fourth segment which is broadly reddish yellow; first segment without median marginals, second with one well developed pair; third and fourth segments each with a marginal row of eight to ten stout but not very long bristles; pollen bands interrupted above by a narrow median vitta and in a rear view sharply limited at the sides on intermediate segments; genital segments reddish yellow, first shining and bare; second segment at middle above beset with short black hairs; inner forceps divided but not strongly divergent, in profile slightly bowed and tapering evenly to a pointed tip, which is blackish in color; outer forceps as long as inner ones but considerably broader, tapering rapidly outward to just before the apex, thence expanded into a spatulate tip bent toward apex of inner forceps; fifth sternite prominent, the lobes separated by a broad V-shaped incision and clothed with delicate black hairs. Legs shining black, except hind surface of front femur which is gray pollinose; claws and pulvilli from one-half to almost equal the length of last tarsal segment. Costal spine not developed.

FEMALE.—Front at base of antennæ equal the eye width; arista thickened on basal three-fifths; cheek about one-third height of eye; first genital segment somewhat compressed at sides and ridged above, second segment retracted showing the usual slitlike genital opening which is beset with a marginal row of inwardly directed bristly hairs; claws and pulvilli short.

Length: Male, 5.5 to 6.5 mm.; female, 7 mm.

Holotype: Male, College Station, Texas, April 18, 1935 (H. J. Reinhard). Paratypes, one male same data as holotype and one female, College Station, Texas, May 5, 1934 (H. J. Reinhard).

Eumacronychia agnella new species

A small species with the front uniform in width from anterior extremity to vertex; first genital segment beset with black hairs near middle above.

MALE.—Front at level of antennal base equal to or slightly exceeding width of eye; parafrontals grayish white pollinose and practically bare; antennæ extending to lowest fifth of face, reddish yellow with third segment more or less infuscated and about three times longer than second; arista blackish, thickened on basal two-fifths to middle, slender beyond; parafacials apparently bare, with dense white subshining pollen; cheek sparsely haired on lower part, nearly one-fourth eye height; palpi yellow, slender but slightly thickened before apex; vibrissal axis of head three-fourths the length of antennal. Scutellum with two pairs of long marginal bristles, the apicals reduced to small hairs. Abdomen rather slender, black with at least the apex of fourth segment reddish; pollen bands on intermediate segments indented but not completely interrupted along the dorsal median line; median marginal bristles on second segment variable (four specimens without any, four with only one bristle developed, and one with a distinct symmetrical pair); no median marginals on the basal segment; third and fourth segments each with a marginal row of about six bristles, which sometimes are irregularly developed on the former; genital segments reddish, smaller than usual and in repose not prominently extruding from tip of abdomen; inner forceps rather short, contiguous to shortly before apex thence divergent; outer forceps a little longer than inner ones and in profile about twice as thick, narrowest just before apex which is broadly rounded and produced into an acute tooth at the posterior extremity; penis rather long and flattened, bowed forward near middle terminating in a pale membraneous hood; lobes of fifth sternite moderately exposed, yellow, clothed with fine black hairs. Legs black, rather short and stout; femora not conspicuously villous; claws and pulvilli short. Costal spine minute or vestigial.

FEMALE.—Front gradually widening from vertex downward, at antennæ almost one and one-half times the eye width; antennæ wholly reddish yellow, third segment barely two and one-half times length of second; arista reddish yellow on thickened part, darker beyond; cheek one-third eye height; abdominal segments one and two without median marginal bristles; third bearing a stout pair besides a weaker lateral marginal one; first genital segment broadly and evenly rounded above; genital opening slitlike, with a marginal row of short black bristly hairs.

Length: Male, 3 to 5 mm.; female, 6 mm.

Holotype: Male, College Station, Texas, July 17, 1923 (H. J. Reinhard). Paratypes, eight males and one female, College Station, July 14 to 17, 1923 (H. J. Reinhard).

Eumacronychia sternalis Allen

Eumacronychia sternalis Allen, Proc. U. S. N. M., Vol. 68, p. 89, 1926.

The elongated claws and pulvilli in the male sex at once distinguish the species from *agnella*, to which it seems most nearly related. The outer genital forceps, as viewed from the side, are hardly as thick as the inner pair and terminate in a broad oblique tip bearing a small acute tooth on the hind side. As in *agnella*, the first genital segment bears a few black bristly hairs behind the middle above.

Twenty-four specimens (both sexes), College Station, Texas, April to October, 1917-36 (H. J. Reinhard).

Holotype in the U. S. National Museum. Type Locality: Galveston, Texas.

Eumacronychia montana Allen

Eumacronychia montana Allen, Proc. U. S. N. M., Vol. 68, p. 88, 1926.

Very similar to the following species, with which it may be confused without reference to the male genitalia. In the present form the outer forceps, as viewed from the side, are broadly bowed and taper to sub-acute tips.

Two specimens (male and female) labeled "Utah 1924" lack median marginals on the second abdominal segment and a second male from Arizona has but one of the bristles developed. The original description, which is largely in the form of a comparison with *decens*, does not specifically mention the abdominal chaetotaxy of the type series (two males).

Holotype in the U. S. National Museum. Type Locality: Mesilla Park, New Mexico.

Eumacronychia tortilis new species

MALE.—Front at antennæ distinctly less than the eye width and gradually widening toward vertex; parafrontals grayish white, bearing a few short black hairs on upper extremity and bare below; parafacials silvery white, bare or sometimes with minute inconspicuous pale hairs; antennæ reddish yellow, third segment slender and nearly four times as long as second; arista brownish, thickened on basal three-fifths; palpi reddish yellow, slender but a trifle swollen apically; cheek one-fifth to one-fourth the eye height; vibrissæ almost half the length of second antennal segment above front border

of oral margin; vibrissal axis of head about two-thirds as long as the antennal axis. Scutellum bearing two pairs of large marginal bristles, the apical ones greatly reduced in size and sometimes appearing as fine decussate hairs. Abdomen moderately slender, black except fourth segment, which is wholly reddish yellow; pollen bands sharply defined, tapering on sides of segments two and three but continuing on venter, not interrupted at middle above; first segment without, second with a pair of median marginal bristles; third with a marginal row of six to eight, fourth with ten moderately strong bristles; genitalia reddish, large and prominent; first genital segment faintly pruinose, bare on entire upper surface; inner forceps divided as usual beyond middle but hardly at all divergent, tips rather blunt, blackish; outer forceps barely exceeding length of inner ones, in profile broad at base tapering rapidly to middle thence obviously twisted on long axis and terminating in a flattened spatulate tip; fifth sternite with a broad V-shaped incision, the lobes not conspicuously exposed, bearing longish fine black hairs along inner margin. Legs black; hind femur moderately villous along lower edge; fore claws and pulvilli about equal the length of last tarsal segment. Wings subhyaline, third vein setulose about halfway to small cross vein; costa without a distinct spine.

FEMALE.—Front at antennæ distinctly exceeding the width of eye; third antennal segment rather wide and about three times as long as second; cheek one-fourth the eye height; median marginals on second abdominal segment small or frequently absent; first genital segment somewhat compressed and ridged along median line above; claws and pulvilli short.

Length: 6.5 to 8 mm.

Holotype: Male, College Station, Texas, July 5, 1917 (H. J. Reinhard). Paratypes, ten males and thirteen females, College Station, July 1–17, 1917, May 5, 1918 (H. J. Reinhard); one male, Steins, New Mexico, July 4, 1917, no collector's label; and one male, Deming, New Mexico, July 15, 1917 (R. C. Shannon).

Eumacronychia decens Townsend

Eumacronychia decens Townsend, Trans. Am. Ent. Soc., Vol. 19, p. 99, 1892; Allen, Proc. U. S. N. M., Vol. 68, p. 86, 1926.

The descriptions given in the above listed references supply most of the essential details except with respect to the genitalia. The following items may be added: Inner forceps of male widely separated and somewhat bowed as viewed from behind; penis geniculate far before the middle, distal segment longer than inner forceps, decidedly flattened or very thin in profile; viewed from behind the distal segment is black with a narrow pale lateral margin, broad at the base and tapering slowly to a narrow emar-

ginate tip. In the female the first genital segment is usually evenly rounded above but sometimes shows a slight median ridge at the apical extremity. The female specimen from College Station in the collection of the late James S. Hine, identified as *decens* by Allen, was collected by the writer. It is one of the series described herein as *tortilis*. There appear to be no authentic records of *decens* from Texas.

One male and one female, Riverside, California, April 11, 1933, and one male, Ontario, California, April 5, 1933, all taken by A. J. Basinger; two females, Victorville, California, April 25, 1936 (H. A. Bess); one male and one female, labeled California, May 1929 and August 1927, without precise locality or collector's label; and two females, Rillito, Pima Co., Arizona, May 2, 1935 (A. J. Basinger).

Holotype in the University of Kansas Museum. Type Locality: Las Cruces, New Mexico.

***Eumacronychia proluxa* new species**

MALE.—Front at antennal base equal to width of eye and widening slightly toward vertex; parafrontals and parafacials silvery pollinose on yellow ground color, the former with only a few short hairs on upper part; antennæ reddish yellow, third segment somewhat darker, rather slender and about three times length of second; arista brownish, thickened on proximal two-fifths and slender beyond; facial ridges bare, parallel nearly to lower extremity then distinctly converging to the vibrissæ, which are well above oral margin; parafacial widening downward to exceed the width of facial depression, clothed with very minute or microscopic pale hairs; palpi reddish yellow, slender and as usual a trifle thickened apically; cheek clothed with black hairs on lower border, almost two-fifths the eye height; antennal axis of head at least one-fourth longer than the vibrissal. Scutellum with two strong marginal bristles besides a weak decussate apical pair. Abdomen elongate, conical fourth segment reddish yellow, preceding ones black; pollen bands sharply limited on sides of intermediate segments, not interrupted at middle above but showing a very narrow obscure dark stripe in most views; second segment with a pair of stout median marginals, none on the first segment; two distal segments each with a marginal row of about eight good-sized bristles; genitalia large and prominent, reddish yellow except forceps, which are blackish; first genital segment bare on entire upper surface, second rather evenly beset with short black bristly hairs; inner forceps slender, divided from near base to tip but hardly at all divergent; outer forceps fingerlike, shorter than inner ones and in profile hardly as thick, the tips blunt; penis rather short and thick, terminating in a swollen tip bearing a pale transparent membrane on the hind side; fifth sternite with a deep broad U-shaped incision,

the lobes prominent with the inner margin at the median angle acutely produced inwardly, clothed with numerous long slender black hairs. Legs black, moderately stout; femora villous; fore claws and pulvilli exceeding the combined length of last two tarsal segments. Wings sub-hyaline, not reaching the tip of abdomen; costal spine not developed.

FEMALE.—Front at antennæ distinctly exceeding the eye width; third antennal segment shorter and broader than in male; first genital segment not compressed at sides and broadly rounded above; claws and pulvilli short.

Length: Male, 9.5 mm.; female, 5 mm.

Holotype male, and allotype female, on one pin, Galveston, Texas, August 30, 1931 (H. J. Reinhard). Paratype, one male, same data as holotype and allotype.



THYSANOPTERA FROM NORTHERN NEW JERSEY WITH DESCRIPTIONS OF NEW SPECIES

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The species listed herein include only those of which the author has specifically determined specimens from the region discussed. Some apparently new species represented by uniques or inadequate material are not described. Collecting has not been at all intensive, and many species, even very common ones, that occur in this section of the United States have not been taken. I owe much material to Mr. W. S. Fields, of the Bureau of Entomology and Plant Quarantine, whose records are followed by his initials; specimens collected by others have their names given in full. Records with no name or initials following are those of the author. Paratypes of all species have been deposited in the collection of Dr. H. Priesner.

LIST OF SPECIES

Aeolothripidae

- Aeolothrips albicinctus* Hal. Demarest, May 10, on grass.
W. S. F.
Ae. bicolor Hinds. Demarest, Sept. 6, on grass. W. S. F.
Ae. fasciatus (L.). Demarest, Sept. 6, on *Solidago*. W. S. F.
Ae. melaleucus Hal. Demarest, June 26, on black locust, abundant.
Ae. versicolor form *similis* Priesn. Morganville, June 4, on *Syringa*, E. Kostal. Alpine, May 16, on oak, abundant.
Ae. vittipennis Hood. Demarest, May 11, on grass. W. S. F.
May 30, on black locust.

Heterothripidae

- Heterothrips arisaemæ* Hood. Demarest, everywhere throughout the season in flowers of *Arisaema*

Thripidæ

CHIROTHRIPINÆ

Chirothrips manicatus Hal. and form *adusta* Priesn. Throughout the season on grasses, everywhere.

C. spiniceps Hood. Demarest, Aug. 19 and Sept. 6, on grass. W. S. F.

Aptinothrips rufus (Gmel.). Throughout the season, on grass.

SERICOTHRIPINÆ

Sericothrips annulipes Hood. Demarest, June 26, on black locust, abundant.

S. baptisiae Hood. Demarest, June 24, July 5, on *Baptisia*, abundant. W. S. F.

S. cingulatus Hinds. Demarest, June 6, on white clover. W. S. F.

S. interruptus Hood. Montville, July 28, abundant on foliage of hickory and birch.

S. sambuci Hood. Fort Lee, July 18–Aug. 25, common on leaves of *Sambucus*.

Scirtothrips brevipennis Hood. Montville, July 27, beaten from red cedar.

S. niveus Hood. Chatham, June 16 and 27, on *Cornus* leaves.

S. D. Whitlock. Demarest, May 30, on *Cornus* leaves, abundant.

S. ruthveni Hood. Demarest, May 30, on *Kalmia* terminal shoots, abundant.

Anaphothrips obscurus (Mull.). Common throughout the season on grasses.

Leucothrips piercei (Morg.). Fort Lee, common on *Tilia* leaves, May 28, July 25 to late August.

Dendrothrips ornatus (Jabl.). Chatham, Aug. 8, on leaves of *Syringa*, A. G. Harley. Fort Lee, throughout its season, so abundant on California privet in August that the leaves appeared gray.

THRIPINÆ

Odontothrips loti (Hal.). Demarest, June 24, July 5, common on *Baptisia* leaves. W. S. F.

Scolothrips sexmaculatus (Perg.). Montville, July 27, on cedar.

Frankliniella fusca (Hinds). Common throughout the season on grasses.

F. stylosa Hood. In spring common in various flowers.

F. tritici (Fitch). Common throughout the region.

Bregmatothrips iridis Wats. Demarest, June 25 to Aug. 30, common on *Iris*, with macropterous females occasionally taken. W. S. F.

Taeniothrips simplex Mor. Common on *Gladiolus*, some seasons completely ruining most of the flowers.

T. betulæ Cwfd., n. sp. Fort Lee, on leaves of *Betula*, July 10-24. Description following.

Ctenothrips bridwelli Frankl. Demarest, abundant on skunk cabbage. Found early in spring and in mid July. W. S. F.

Oxythrips divisus Hood. Alpine, May 1, on pine.

Pseudothrips inæqualis (Beach). Fort Lee, July 18, in terminal leaves of willow.

Microcephalothrips abdominalis (Crawf.). Common in flowers of Compositæ in summer and autumn.

Thrips impar Hood. Demarest, June 26 to Aug. 25, abundant on *Impatiens*. W. S. F. and J. C. C. Montville, Aug. 25, on *Impatiens*.

T. monotropæ Hood. Montville, July 27, on *Monotropa*.

T. tabaci Lind. Throughout the season on many plants.

T. thalictri Hood. Demarest, July 11, on leaves *Thalictrum polygamum*. W. S. F. and J. C. C.

T. walteri Cwfd. Fort Lee, Sept. 12 to 19, in large numbers on leaves of *Eupatorium* in shady woods.

Merothripidæ

Merothrips morgani Hood. Ft. Lee, Aug. 15, a single dealated macropterous female. Under bark of a dry, dead, standing, hickory sapling, running very actively.

Phlæothripidæ

PHLÆOTHRIPINÆ

Haplothripini

Haplothrips niger (Osb.). Commonly throughout the region, especially in flowers of daisies.

Karnyothrips dodgei (Hood). Fort Lee, Aug. 15, under bark of dead hickory sapling.

Neoheegeria verbasci (Osb.). Found everywhere on *Verbascum*.

Bagnalliella yuccæ (Hinds). To be found wherever *Yucca* occurs.

Leptothrips mali (Fitch). On leaves of various trees throughout the region.

Hoplothripini

Liothrips caryæ (Fitch). Throughout the region, in and around galls on hickory leaves, in May and June.

L. citricornis Hood. Taken commonly at the same time as the preceding and also on leaves of various plants.

L. brevicornis Hood. Fort Lee (J. C. C.) and Demarest (W. S. F.), in terminal shoots of sassafras, late in May to early in July.

L. castaneæ Hood. Demarest, early in July on leaves of chestnut. W. S. F. and J. C. C.

L. umbripennis Hood. Alpine, May 1, on pine, May 6, on oak. Denville, mid July, so abundant on leaves of chestnut oak as to distort the leaves. M. H. Sartor.

Neothrips corticis Hood. Demarest, April 18, and Cresskill, May 9 and Sept. 5, under bark scales of live apple trees.

Poecilothrips ornatus (Hood). Throughout the region found commonly from late in spring to autumn on bark of dead branches where the bright red and white nymphs may be seen running busily about.

Rhynchothrips pruni Hood. To be found at any time of the year under bark scales of live *Prunus*.

R. buffæ (Hood). Fort Lee, July 10, in cracks of bark of live maple tree.

R. russelli Hood. Demarest, abundant on leaves of Virginia creeper, May 26–July 3.

R. tridentatus (Shull). Fort Lee, abundant under bark scales of a live tree of the white oak group in August.

R. usitatus Hood. Everywhere on leaves of *Rhus copallina* late in June and early in July.

Hoplothrips karnyi (Hood). Throughout the region under bark

of moist dead branches. Various dates through the season.
W. S. F. and J. C. C.

- H. major* (Hood). To be found everywhere under moist bark of dead branches or tree trunks or on and under fungi on dead trees. Adults can be taken at any time of the year.
- H. (Trichothrips) ambitus* (Hinds). Fort Lee, mid August, under bark of dry dead standing hickory saplings.
- H. (T.) angusticeps* (Hood). Everywhere under dead moist bark and on polypores.
- H. (T.) flavicauda* (Morg.). Demarest, Sept. 9, beaten from a large polypore. W. S. F. Cresskill, early in September on young succulent polypores on dead birch.
- H. (T.) myceticola* Cwfd., n. sp. Cresskill, on polypore on dead birch, Aug. 28–Sept. 6. Description following.
- H. (T.) fieldsi* Cwfd., n. sp. Fort Lee, Apr. 11, under bark of a dead *Sambucus* stem. Description following.
- Zygothrips americanus* Hood. Under bark scales of live hickory and apple trees throughout the region.

Phlæothripini

- Phlæothrips chapmani* Hood. Fort Lee, July 24, on dead branches of *Cornus* in company with the following.
- P. picticornis* Cwfd., n. sp. Fort Lee, July 17–31, on dead *Cornus* and *Carpinus*. Description following.
- Hoplandrothrips funebris* Hood. Chatham, a single male, flying, Sept. 19. S. D. Whitlock.
- H. microps* Hood. Fort Lee, Aug. 7, in coleopterous burrow in dry, dead, standing, hickory sapling, and under bark of dead ash sapling.
- Neurothrips magnafemoralis* (Hinds). Alpine, May 1, on pine. Demarest, Aug. 7, on *Rhus*. Fort Lee, Aug. 18, on dead branches of chestnut.

MEGATHRIPINÆ

- Elaphrothrips tuberculatus* (Hood). Denville, July 14, on leaves of chestnut oak. M. H. Sartor.
- Megalothrips spinosus* Hood. Fort Lee, mid August, under bark of various dry dead branches, when males were not uncommon. Also on dead branches of *Cornus* sp.

DESCRIPTIONS OF NEW SPECIES

Taeniothrips betulæ new species.

FEMALE.—Length about 1.1 mm. Dark brown, head and especially thorax often with a reddish tinge; legs almost concolorous with body, femora lighter basally, tibiae somewhat lighter in color and paler at bases and apices, tarsi yellow; antennæ brown, with segment 3 yellow, tinged with brownish, segment 4 light brown, segments 5 to 8 darker than 1 and 2; all body and wing bristles very stout and very dark in color; fore vein with two apical bristles close together.

Head (from front of eyes) much wider than long (156μ to 112μ), narrowed behind; cheeks almost straight, with transverse anastomosing lines; ocelli with red crescents; interocellar bristles close together ($14\text{--}16\mu$), $60\text{--}64\mu$ long, slightly in front of a line tangent to front margins of postocelli; postocular row of 4–5 short, weak bristles, the outer strongest, 20μ long; segment 1 of antennæ light brown, 2 dark brown, 3 yellow, tinged brownish, 4 light brown, 5–8 very dark brown; third antennal segment with a long pedicel; segments 4 and 5 with short pedicels; segments 5 and 6 closely united; segment 3 narrowed toward tip but not vasiform, 4 somewhat narrowed at apex, 5 gradually widened from base to near apex, thence slightly narrowed; antennal lengths in μ :

1	2	3	4	5	6	7	8
24	38	48	44	36	52	8	16

Prothorax wider than long (184 to 142μ), with faint transverse anastomosing lines, disk with scattered short bristles of which a pair on anterior margin, one on lateral margins, and one on disk in front of inner postangular spines are longer and stronger (20μ) than the others; outer and inner postangulans 60μ long, between them a short bristle, postmargin between postangulans with two pairs of bristles on each side, the inner pair strong, long, (36μ), outer pair much weaker, 18μ long; wings very dark brown; costa with 18 to 21 bristles, fore vein with 6 or 7 basal and 2 bristles close together near apex; hind vein with 10–12, usually 10 bristles; hind wing basally with a dark median streak; comb on eighth segment thickset, complete, bristles 24μ long; inner pair of bristles on ninth segment 108μ , outer 120μ long; fore-wings $675\text{--}720\mu$ long.

MALE.—Length 0.85 mm. Reddish yellow, legs slightly lighter in color; antennæ brown, with basal and apical segments lighter than in female; segment 1 yellow, tinged with brown; 2 brown, very slightly darker than 3; 4 brown, lighter at base; 5 yellowish just beyond pedicel, brown beyond; 6 to 8 dark brown. Length of antennal segments in μ :

1	2	3	4	5	6	7	8
24	32	48	40	26	44	8	16

On the ninth abdominal segment between the major bristles of posterior angles and slightly more forward a row of 4 dark-brown bristles, the outer

pair longer (26μ) and latero-cephalad of this row a single, weaker, light-colored bristle on each side; caudad of the row a pair of short, weak, light-colored bristles situated farther apart than the median pair of the row.

Type locality.—Fort Lee, N. J.

Host plant.—*Betula populifolia*.

Type.—Cat. No. 52667, U. S. National Museum. A pair taken in copula, July 17, 1937.

Many paratypes, from the same place, a single female taken July 10, 1937, many females and 10 males taken July 17, 1937, and a few taken July 24, 1937, all collected by the author.

This species is most closely related to *T. salicis* Reuter of Europe, and Dr. Priesner has kindly compared paratypes, which are deposited in his collection, with the European species. He states that in the female of *salicis* the prothoracic postangulars are at most 3μ wide at base, the interocellar bristles on a level with fore margin of hind ocelli or even somewhat back of this and 22 to 25μ apart, that the head is 92 to 96μ , measured from in front of eye, or 108μ in total length, the wing length 744–848 μ , that the major bristles are lighter in color, and that the costal bristles are more numerous, being 23–25.

T. betulæ has prothoracic postangulars $3.3\text{--}4\mu$ wide at base, interocellars placed farther forward and only about 14μ apart, head much longer, wing much shorter, body bristles almost black, and costal bristles fewer in number. The male *betulæ* has the bristles on the body and wing darker than in *salicis*, antennal joint 6 much shorter, all bristles much shorter and thicker, and the bristles on the ninth tergite arranged practically as in *salicis*. However, in his Monograph of Thysanoptera of Europe Priesner states that the posterior pair of bristles on the ninth segment are about as long as those in the row of 4.

Hoplothrips (Trichothrips) myceticola new species.

FEMALE (*brachypteros*).—Length about 1.1 mm. (fully distended, 1.65 mm.). Body almost uniformly dark brown, including legs and antennæ; with red pigment in thorax and abdomen; tube yellow; eyes normal in size; ocelli present, with red crescents; major head and thoracic bristles brown with hyaline tips, blunt or mostly slightly dilated at tips.

Head longer than wide, with faint transverse anastomosing lines; distinctly wider than eyes; sides almost straight, slightly converging behind

and slightly constricted from about two-thirds back of eye to base of head; eyes directed forward, with outer sides almost straight and with sides of head extending forward one-half the eye length so that in profile only about seven facets are exposed; fore ocellus somewhat directed forward; antennæ brown, with segment 1 lightened basally, 2 yellow, brownish at sides, 3 yellow in basal one-half, brown beyond, 4-8 brown slightly increasingly so to tip of antennæ; segments 3-8 pedicellate; segment 3 with inner side almost straight, widened for four-fifths the length thence strongly narrowed to apex, outer side distinctly, almost evenly, strongly convex from beyond pedicel, with widest part nearer base than widest part of inner side; segments 4 and 5 almost evenly convex at sides; 6 and 7 narrower, barrel-shaped; 8 lanceolate; mouth cone short, not reaching middle of prosternum; sense cone formula: 3, 1-2; 4, 2-2; 5, 1-1⁺; 6, 1-1⁺; 7, 1 dorsally.

Prothorax more than twice as wide as long, slightly emarginate anteriorly; all major bristles thick except the slender anterior marginals; pterothorax almost square, sides parallel. Legs almost as deep brown as body, with apices of femora and bases and apices of tibiæ lighter, especially on anterior legs; all tarsi yellow, with a dark spot at tip; fore femora enlarged; fore tarsi unarmed; wing-retaining bristles, one pair on segments 2-7 strongly and doubly arcuate only on 5-7; abdominal tergites short and broad, segment 5 being about 80 μ long for total chitinized area or 48 μ from basal carina to apex and about 300 μ wide.

Measurements (in μ): Head, length (from front of eyes) 184, greatest width 164, postoculars 12 from side of head, 14 back of eyes; antennæ:

1	2	3	4	5	6	7	8
32	48	50	46	44	40	36	39

Total length of antennæ (distended) 430; thorax, length at middle 112, width 250; tube length 100, apical width 32, basal width 64; setal measurements: Postoculars 56, anterior angulars (16 to) 36, anterior marginals (18 to) 24, midlaterals 20, epimerals 56, coxals 22, on ninth segment outer and inner 56, on tenth segment 128.

MALE (*brachypterous*).—Length (slightly shrunken) 0.95 mm. Similar to female but fore femora greatly enlarged; fore tibiæ slightly thickened and transversely wrinkled; fore tarsi with a long slender tooth (26 μ); segment 2 of antennæ darker; 3 yellow only to just beyond pedicel, rest brown, increasingly so toward tip; abdominal segment 9 yellowish in apical two-thirds fading to brown at sides.

Type locality.—Cresskill, N. J.

Additional locality.—Washingtonville, N. Y.

Type.—Cat. No. 52668, U. S. National Museum.

The types and paratypes were taken on young *Polyporus betulinus*, on standing dead gray birch, *Betula populifolia*, Sept. 6, 1937; other paratypes from the same locality and host taken

August 28 and 29 and September 5 and 6, 1937, all collected by the author. The paratypes from Washingtonville, N. Y., were from under the bark of a dead elm log, August 3, 1937, L. L. Pechuman, collector.

The male allotype, which is a poor specimen, is the only specimen of that sex taken.

Of the species having the fore tarsi unarmed in the female, *brevicruralis* Shull, *fuscus* Morgan, and *hoodi* Morgan have the eighth antennal segment with a broad base; *flavicauda* Morgan differs in having no ocelli, eyes small, only two sense cones on antennal segment 3, and head usually very distinctly lighter colored anteriorly than posteriorly; *fuscicornis* Hood is a much larger species with tube 0.8 length of head, terminal bristles three-fourths length of tube, and anterior angular and anterior marginal prothoracic bristles subequal in length, while in *myceticola* the anterior angulars are usually much longer than the anterior marginals.

Hoplothrips (Trichothrips) fieldsi new species.

FEMALE (*macropterous*).—Length (distended) 2.42 mm. Head, thorax, and tube brown, rest of abdomen and legs yellow, abdomen with segments discally and femora stained with brown; antennæ with segment 1 brownish; 2–3 yellow tinged with brown, and 3 at apex light brownish; 4–8 deep brown with bases of 4 and 5 usually yellowish, segment 4 enlarged, wider than other segments and with many micro-sense cones on under side; 5 with many, and 6 with five to eight similar sense cones.

Head somewhat lighter brown than thorax, wider than long, with straight parallel sides, wider than eye width; eyes two-fifths length of head; ocelli large, lateral ocelli near eyes, front ocellus directed forward; postoculars pointed, far apart, 16 μ from eyes; head with delicate transverse anastomosing lines; mouth cone reaching beyond middle of prosterium; antennæ with segments 3–7 pedicellate, 8 not narrowed basally; segment 3 broadly obconical, narrowed abruptly from widest point to apex, distinctly circularly wrinkled at base; 4 enlarged, almost barrel-shaped, and with many (circa 30) micro-sense cones ventrad on more than apical half; 5 with sides parallel, narrowed basally and apically, with many (circa 15) micro-sense cones ventrad on apical half; 6 slightly widening apicad, with straight sides, ventrad 3–6 micro-sense cones on apical half; major sense cones on segments 5–6 slender; sense cone formula: 3, 1–1; 4, 1–1; 5, 1–1⁺; 6, 1–1⁺; 7, 1 dorsally; prothorax more than twice as wide, including coxæ, as long; major bristles pointed (with epimerals, postmarginals, and coxals at times minutely blunt or epimerals and coxals slightly dilated); anterior marginals rudi-

mentary; all wings distinctly brownish, with eight or nine double-fringe hairs; legs yellow, femora tinged with brownish, tarsi brown-spotted apically; fore femora greatly enlarged; fore tarsi with a large tooth; abdomen yellow, segment 1 brown, discs of other segments medially brownish; tube dark brown, lighter basally and apically; two pairs of wing-retaining bristles on segments 2-7, both slender, anterior pair short, posterior pair long, distinctly doubly arcuate only on segment 5; marginal abdominal bristles long, sharply pointed.

Measurements (in μ): Head: Length (from front of eyes) 200, width across eyes 228, greatest width 244, distance between postoculars 212. Prothorax: Width, including coxæ, 416, length medially 196. Tube: Length 206, basal width 92, apical width 40. Antennæ:

	1	2	3	4	5	6	7	8
Length	48	66	68	82	70	60	60	46
Width	40 (apical)	40	45	50	40	34	28	18

Setal measurements: Postoculars 84, anterior angulars 46, midlaterals 76-80, epimerals 90, postmarginals 84, coxals 52, on ninth abdominal segment (outer) 132, (inner) 108, on tenth segment 192.

MALE (*brachypterous*).—Length (distended) 2.10 mm. Similar to female but more uniformly colored, the head and thorax hardly as dark in color, abdomen more uniformly brownish but much lighter than tube; eyes small, about five facets in outline; ocelli absent; antennal segments 1-3 uniformly yellow, tinged with brown; 4-8 brown, increasingly so toward tip of antennæ; sides of head slightly curved; fore femora greatly enlarged; fore tibiæ thickened; tarsal tooth longer and thicker basally than in female; antennal segment 3 not so broadly obconical, segment 4 not enlarged; segments 4-6 ventrad with 2-4 apical micro-sense cones; wing-retaining bristles not thickened or arcuate.

Measurements in μ : Head: Length 180, width across eyes 184, greatest width 220. Prothorax: Width, including coxæ, 414, length medially 220. Tube: Length 180, width at base 88, at apex 40. Setal measurements: Postoculars 86, anterior angulars 80, midlaterals 82, epimerals 82, postmarginals 76, coxals 52. Antennæ:

	1	2	3	4	5	6	7	8
Length	48	64	64	64	64	60	48	40
Width	36 (apical)	36	36	36	32	30	26	16

FEMALE (*brachypterous*).—Length (fully distended) 3.0 mm. Similar to the macropterous form but with antennal segments 2-3 more distinctly brown; abdomen more uniformly brown; eyes small, about three facets in outline; antennæ very similar to those of brachypterous male; tarsal tooth about as in brachypterous male; ocelli absent. Antennæ in μ :

1	2	3	4	5	6	7	8
52	62	68	66	64	60	60	40

Described from a long series of specimens with the following records:

Type locality.—Olive Bridge, Ulster County, N. Y.

Under bark of a dead branch, August, 1936, W. S. Fields collector.

Other localities are as follows:

District of Columbia: Under bark of dead alder, May 16, 1937, J. E. Walter collector; under bark of a dead willow branch, June 9, 1937, J. E. Walter collector; under bark of dead *Sambucus* stem, January 12, 1937, J. E. Walter collector; under bark of a dead hanging branch of black locust, May 2, 1937, J. E. Walter collector; under bark of a dead branch of black walnut on ground, May 1, 1937, J. E. Walter collector.

New Jersey: Fort Lee. Under bark of a dead *Sambucus* stem, April 11, 1937, J. C. Crawford collector.

Type.—Cat. No. 52669, U. S. National Museum.

Dedicated to Mr. W. S. Fields, from whom I first received specimens of this species.

Nearer *Hoplothrips semicæcus* Uzel of Europe than any American species, none of which have antennal segments 4–6 ventrad with a series of micro-sense cones in the known macropterous forms. The macropterous form of *semicæcus* has antennal segments 7–8 longer, 4 less thickened, only one or two micro-sense cones ventrad on 6 and fewer of them on 4–5; in the brachypterous form *semicæcus* has the tube longer, bristles on segment 9 longer, and joint 3 of antennæ with the basal wrinkles much less conspicuous. Dr. H. Priesner has kindly compared this species with the European and furnished the foregoing notes.

It should be noted that while in *fieldsi* the major bristles of the prothorax are mostly sharply pointed, those of the posterior margin are often blunted or the epimerals slightly expanded at apex.

***Phlaeothrips picticornis* new species.**

FEMALE.—Holotype (*macropterous*): Length about 2.4 mm. (fully distended, 3.5 mm.). Dark brown (in life whole insect almost black), abdomen somewhat lighter, with much red pigment in thorax and abdomen; antennæ dark brown, with bases of segments 3–6 light yellow, abruptly dark brown beyond; legs dark brown, fore tibiæ apically and all tarsi yellow with a dark spot at tip; fore tarsi armed with a large tooth; abdominal segments

3-8 anteriorly with a small dorso-lateral snow-white spot on each side, often also one posteriorly or these irregularly connected to form a stripe.

Head $333\ \mu$ long (from front of eyes), widest just back of eyes ($267\ \mu$), narrowed behind; cheeks gently rounded and at rear with a slight necklike constriction; postoculars absent; head with faint transverse anastomosing lines; cheeks in outline with three or four short spines, the posterior one much longer and stronger than the others; anterior ocellus directed forward, situated on a prominence which has longitudinal anastomosing lines; anterior ocellus farther from posterior ocelli than they are from each other; antennal segment 1 concolorous with head; 2 somewhat lighter; 3 yellow in basal one-third or more, mottled with light brown beyond and with a yellowish tip; 4 clear yellow in basal one-third, brown beyond, with tip lightened; 5 yellow to just beyond pedicel, brown beyond, with tip lightened; 6 with pedicel yellow; rest of antennæ dark brown, with base of 7 lighter; segments 3-6 with long pedicels, that of 6 broader, 7 and 8 closely united. Sense cone formula:

3, 1-2; 4, 2-2; 5, 1-1⁺; 6, 1-1⁺; 7, 1 dorsally

Length of antennal segments in μ :

1	2	3	4	5	6	7	8
60	80	96	88	80	72	52	40

Prothorax $200\ \mu$ long, $400\ \mu$ wide; major bristles dilated at tips, light brownish, with epimerals and coxals almost hyaline; lengths of prothoracic bristles: Anterior angulars $40\ \mu$, anterior marginals $24\ \mu$, midlaterals $20\ \mu$, epimerals $92\ \mu$, postmarginals $40\ \mu$, coxals $40\ \mu$; fore femora swollen; fore tibiae somewhat enlarged, abruptly bent near base, transversally wrinkled; legs about concolorous with body, fore tibiae somewhat lighter and yellow at tips, fore tarsi with a long, straight, slender tooth arising near base of first tarsal joint; scale and extreme base of fore wings dark brown, rest of wing very lightly clouded, more distinctly so medially, with 11 (9-12) accessory fringe hairs; prothorax reticulated, especially apparent at anterior angles.

Abdomen with anterior segments somewhat lighter brown, with faint, transverse, anastomosing lines, becoming reticulated at sides, reticulations covering segment 9; segments 2-8 carinate at base, segments 2-7 with two pairs of brown, doubly arcuate, wing-retaining bristles, the posterior pair strong, the anterior pair much shorter and weaker; major lateral bristles subhyaline, capitate; tube $216\ \mu$ long, lighter at tip, sides straight to near base, $88\ \mu$ wide at base, $48\ \mu$ wide at apex, terminal bristles $200\ \mu$ long.

MALE.—Allotype (*macropteros ædymer*): Length 2.3 mm. (distended, 3 mm.). Similar to the female, posterior spine on cheeks longer than in female ($34\ \mu$), fore tarsal tooth larger and broad basally; anterior angular bristles on prothorax set well back from anterior margin, almost $200\ \mu$ long, anterior marginals minute, midlaterals hardly $16\ \mu$ long, epimerals $88\ \mu$, postmarginals $38\ \mu$, coxals $48\ \mu$, all only slightly brownish, fore coxæ with

several short, very stout bristles caudad; fore femora more enlarged; thickened truncate spines on ninth abdominal segment $56\ \mu$ long, dark brown.

MALE (*gynacoid*).—Length 2.3 mm. Similar, but with prothorax and fore legs not so developed and anterior angular bristles of prothorax $60\ \mu$ long; tooth on fore tarsi not so broad, curved.

Type locality.—Fort Lee, N. J.

Type.—Cat. No. 52670, U. S. National Museum.

Holotype female and allotype male collected on branchlets of the suspended dead top of a dogwood (*Cornus* sp.) tree, July 24, 1937, together with three female and one male paratypes; eight female and four male paratypes taken on same tree, July 17, 1937; one female paratype, July 31, 1937, on suspended dead branch of *Carpinus* sp. From the same locality one gynacoid paratype (the only one taken) and one oedymmer male paratype reared from nymphs collected April 11, 1937, under bark of dead branch (probably beech). One male paratype, Englewood Cliffs, N. J., Aug. 29, 1937, on branch of a fallen dead oak tree. All collected by J. C. Crawford.

Very similar to *Phlaothrips chapmani* Hood, which was taken with it, but differs in having the antennal segments longer, the bases of the intermediate antennal segments light, the fore tibiae yellow apically, the tarsi yellow, the white abdominal marks usually spots instead of a continuous band, the wings infuscated, etc.

BOOK NOTICE

The Fulgorina of Barro Colorado and Other Parts of Panama.

By Z. P. Metcalf. Bulletin of the Museum of Comparative Zoology, vol. LXXXII, No. 5, p. 277-423, pl. 1-23, Cambridge, Mass., Oct. 1938.

Although I have no specific knowledge upon which to base a review of this monograph, I cannot but feel that mention should be made of such works when they appear. All too frequently, excellent monographs pass entirely unnoticed by entomologists in general and find their way only into bibliographies and the hands of a small group of specialists.

Dr. Metcalf's present report is based on collections of fulgorids made by Mr. Nathan Banks, those of the American Museum of Natural History and the United States National Museum, together with a considerable number from Central and South America belonging to the author. Male genitalia furnish the most reliable taxonomic and systematic characters and there are numerous keys to species, genera, tribes and subfamilies supplemented by a wealth of illustrations. In addition, Dr. Metcalf has corrected some past errors and settled some controversial questions. I am sure that students of fulgorids will appreciate this valuable contribution to the literature of this group of insects.—H. B. W.

NOTES ON SOME THRIPS COLLECTED IN THE VICINITY OF BABYLON, LONG ISLAND, N. Y.

BY F. S. BLANTON¹

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During the period from 1931 to 1934 studies have been in progress at the Babylon, N. Y., field laboratory of the Bureau of Entomology and Plant Quarantine to determine whether insects or other arthropods are concerned in the spread of a virus disease of narcissus known as narcissus mosaic. One phase of these studies involved faunistic surveys to obtain information on the kinds and abundance of insects that occurred in narcissus plantings during the growing season and the relation that the insect fauna bear to the incidence of the disease. The insects were collected not only from narcissus within a given planting but also from all weeds and other plant growth present therein at the time of collection, as well as on other plants growing in close proximity to the narcissus planting. It was found that very few insects were able to breed on narcissus, and for this reason it seems evident that the weeds growing in close association with this flower may play an important role by harboring the vector of narcissus mosaic. During the first two seasons, 1931 and 1932, only a few thrips were collected. During 1933 and 1934, however, more extensive collections were made.

Only one insect other than thrips has been found which can breed on narcissus. Three species of thrips, *Frankliniella fusca* Hinds, *F. tritici* Fitch, and *Thrips tabaci* Lind., have this ability. There are several species of insects, however, that use narcissus

¹ The majority of the specimens discussed in this paper were collected by the writer; however, a number were collected by F. A. Haasis and F. J. Spruijt. The writer gratefully acknowledges the assistance rendered by those authorities who have identified the specimens, including J. R. Watson, J. C. Crawford, and Dudley Moulton.

To Dr. Hugh O'Neill the writer wishes to express his gratitude for assisting with the identification of plants and for suggestions from the viewpoint of systematic botany. The writer is responsible for all identifications where only the genus is given.

as an occasional or transitory host and have been observed feeding on narcissus. With the mixed flora usually present in narcissus fields it is not necessary for the insect to confine its feeding to narcissus.

Drake *et al.*² in their study of yellow dwarf of onions found that over 50 species of aphids served as the vector of the virus, but they did not find a single species that could breed or even live on onions for any length of time. For this reason they applied the name "transitory" host to the onion. Narcissus are like onions in this respect and to most species the plant juices are apparently poisonous.

In all tests performed thrips have given negative results as vectors of narcissus mosaic. Two species, *Frankliniella fusca* and *Thrips tabaci*, have been used in the writer's experiments and also by Dr. F. A. Haasis³, who has made extensive tests with *Thrips tabaci*.

Smith and Brooks⁴ have reviewed the literature and have given the kinds of insects responsible for the transmission of virus diseases.

Bailey⁵ has given a very complete review of the literature pertaining to thrips as vectors of plant diseases. This will not be reviewed here except to state that he points out the fact that only three species of thrips have been definitely proved to be vectors of two viruses while others are doubtfully incriminated.

It is quite possible that other species of thrips feed on narcissus, but up until this time the writer has found only the following: 1. *Aeolothrips bicolor* Hinds, 2. *Chirothrips manicatus* Hal., 3. *Frankliniella fusca* Hinds, 4. *Frankliniella tritici* Fitch, 5. *Thrips tabaci* Lind.

Aeolothrips bicolor was taken on narcissus on only a few occa-

² Drake, C. J., Tate, H. D., and Harris, H. M. The relationship of aphids to the transmission of yellow dwarf of onions. Jour. Econ. Ent. 26: 841-846. 1933.

³ Haasis, F. A. A study of narcissus mosaic with notes on other possible virus diseases of narcissus. Unpublished thesis, Department of Plant Pathology, Cornell University, 1935.

⁴ Smith, K. M., and Brooks, F. I. Recent advances in the study of plant viruses. Blakiston, Philadelphia, 1934.

⁵ Bailey, S. F. Thrips as vectors of plant diseases. Jour. Econ. Ent. 28: 856-863. 1935.

sions. *Chirothrips manicatus* is usually fairly common on narcissus during May. Although this species is found on several plants, it seems to be most abundant on grasses. *Frankliniella fusca* was fairly common on narcissus foliage during June and July. *Frankliniella tritici* is abundant on narcissus during the latter part of May, and through June and July, although a few specimens have been found on narcissus in April. This species is associated with many of the grass and weed flowers, and about 75 hosts are recorded in this paper. *Thrips tabaci* occurs quite commonly on narcissus from May until August. This species has also been collected in April. During July of 1934 F. A. Haasis and the writer collected this species in a commercial narcissus planting which showed 90 per cent of the foliage to be injured.

The following list gives the scientific and common names of the host plants followed by the species of thrips found on these plants. In the list immediately following, the host-plant list, the thrips are given alphabetically, together with the localities and the months of the year in which they were collected. The writer realizes that many other species of thrips could perhaps be collected in the vicinity of Babylon, N. Y., but, as mentioned previously, this survey was confined to narcissus plantings and adjacent territory. In spite of these restrictions, however, several species new to New York were found.

Acalypha virginica L., three-seeded mercury. *Frankliniella tritici* Fitch.

Achillea Millefolium L., milfoil. *Frankliniella tritici* Fitch; *Haplothrips leucanthemi* (Schränk); *Haplothrips niger* (Osb.); *Thrips tabaci* Lind.

Agropyron repens (L.) Beauv., quackgrass. *Frankliniella tritici* Fitch.

Agrotis alba L., redtop. *Aeolothrips bicolor* Hinds; *Anaphothrips obscurus* Muller; *Aptinothrips rufus* (Gmelin); *Chirothrips manicatus* Hal.; *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Hoplothrips pergandi* Hinds.

Amaranthus retroflexus L., pigweed. *Chirothrips obesus* Hinds; *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.

- Ambrosia elatior** L., ragweed. *Frankliniella tritici* Fitch; *Thrips nigropilosus* Uzel; *Thrips tabaci* Lind.
- Anagallis arvensis** L., common pimpernell. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch.
- Arctium minus** Bernh., common burdock. *Frankliniella tritici* Fitch.
- Arisæma triphyllum** (L.) Schott., jack-in-the-pulpit. *Ctenothrips bridwelli* Franklin; *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Arrhenatherum elatius** (L.) Beauv., oatgrass. *Frankliniella tritici* Fitch.
- Asclepias syriaca** L., common milkweed. *Aeolothrips fasciatus* L.; *Frankliniella tritici* Fitch; *Leptothrips mali* (Fitch); *Limothrips cerealium* Hal.
- Asclepias tuberosa** L., butterfly weed. *Frankliniella tritici* Fitch; *Frankliniella williamsi* Hood.
- Aster** sp., wild aster. *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch; *Haplothrips subtilissimus* (Hal.); *Thrips tabaci* Lind.
- Azalea** sp., azalea. *Frankliniella tritici* Fitch; *Heterothrips lyoniæ* Hood; *Heterothrips azaleæ* Hood.
- Berberis vulgaris** L., common barberry. *Frankliniella tritici* Fitch; *Haplothrips subtilissimus* (Hal.); *Thrips tabaci* Lind.
- Betula nigra** L., birch. *Aeolothrips bicolor* Hinds; *Thrips tabaci* Lind.
- Brassica campestris** L., rutabaga. *Leptothrips mali* (Fitch); *Thrips tabaci* Lind.
- Carya** sp., hickory. *Frankliniella tritici* Fitch.
- Chenopodium album** L., lamb's-quarters. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Chrysanthemum Leucanthemum** L., ox-eye daisy. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Haplothrips leucanthemi* (Schränk); *Haplothrips niger* (Osb.); *Thrips tabaci* Lind.
- Convolvulus arvensis** L., field bindweed. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Haplothrips subtilissimus* (Hal.).
- Coreopsis lanceolata** L., tickseed. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.

- Daucus carota* L., carrot. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Digitaria sanguinalis* L. Scop., crabgrass. *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Equisetum arvense* L., common horsetail. *Frankliniella tritici* Fitch.
- Erechtites hieracifolia* (L.) Raf., burnweed. *Frankliniella tritici* Fitch.
- Erigeron canadensis* L., horseweed. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Erigeron ramosus* (Walt.) BSP., daisy fleabane. *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch; *Haplothrips leucanthemi* (Schränk); *Haplothrips niger* (Osb.); *Thrips tabaci* Lind.
- Eupatorium* sp., thoroughwort. *Frankliniella tritici* Fitch.
- Fagopyron vulgare* Hill, common buckwheat. *Frankliniella tritici* Fitch; *Limothrips cerealium* Hal.; *Thrips tabaci* Lind.
- Fragaria* sp., wild strawberry. *Frankliniella tritici* Fitch.
- Galinoga parviflora* Cav., quickweed. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Gladiolus*, glads. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Teniothrips simplex* Morison.
- Gnaphalium sylvaticum* L., cudweed. *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch; *Thrips tabaci* Lindeman.
- Habenaria blephariglottis* (Willd.) Torr., white-fringed orchid. *Frankliniella tritici* Fitch.
- Helenium* sp., sneezeweed. *Haplothrips niger* (Osb.); *Limothrips cerealium* Hal.; *Thrips tabaci* Lind.; *Zygothrips harti* Hood.
- Hieracium aurantiacum* L., orange hawkweed. *Frankliniella tritici* Fitch.
- Hypericum* sp., St. John'swort. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Haplothrips leucanthemi* (Schränk); *Thrips tabaci* Lind.
- Iris* sp., iris. *Bregmatothrips iridis* Watson; *Frankliniella tritici* Fitch.
- Lactuca canadensis* L., wild lettuce. *Frankliniella tritici* Fitch.
- Lepidium virginicum* L., wild pepper-grass. *Frankliniella*

- tritici* Fitch; *Haplothrips subtilissimus* (Hal.); *Thrips tabaci* Lind.
- Leucothœ** sp., fetterbush. *Frankliniella tritici* Fitch.
- Lilium canadense** L., wild yellow lily. *Ctenothrips bridwelli* Franklin; *Frankliniella tritici* Fitch.
- Linaria canadensis** (L.) Dumont, old field toad-flax. *Frankliniella tritici* Fitch.
- Linaria vulgaris** Hill, butter-and-eggs. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Malva rotundifolia** L., common mallow. *Frankliniella tritici* Fitch.
- Mollugo verticillata** L., carpetweed. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch.
- Narcissus Pseudo-narcissus** L., daffodil. *Aeolothrips bicolor* Hinds; *Chirothrips manicatus* Hal.; *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Oxalis stricta** L., common yellow oxalis. *Frankliniella tritici* Fitch.
- Panicum** sp., grass. *Anaphothrips obscurus* Muller; *Aptinothrips rufus* (Gmelin); *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch; *Limothrips cerealium* Hal.; *Thrips tabaci* Lind.
- Phleum pratense** L., timothy. *Frankliniella tritici* Fitch.
- Phlox** sp., wild phlox. *Frankliniella tritici* Fitch; *Haplothrips subtilissimus* (Hal.).
- Phytolacca decandra** L., pokeweed. *Frankliniella tritici* Fitch.
- Plantago lanceolata** L., buckhorn plantain. *Chirothrips manicatus* Hal.; *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Haplothrips leucanthemi* (Schrank); *Haplothrips niger* (Qsb.); *Thrips tabaci* Lind.
- Plantago Rugelii** Dene., plantain. *Frankliniella tritici* Fitch.
- Poa palustris** L., grass. *Aptinothrips rufus* (Gmelin); *Chirothrips manicatus* Hal.; *Frankliniella fusca* (Hinds); *Frankliniella nervosa* (Uzel); *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Polygala lutea** L., milkwort. *Aeolothrips bicolor* Hinds; *Frankliniella fusca* (Hinds).
- Polygonum aviculare** L., knotweed. *Frankliniella fusca* (Hinds); *Thrips tabaci* Lind.

- Polygonum Convolvulus** L., cornbind. *Frankliniella tritici* Fitch.
- Polygonum Persicaria** L., lady'sthumb. *Aeolothrips bicolor* Hinds; *Aeolothrips fasciatus* L.; *Chirothrips manicatus* Hal.; *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch.
- Portulaca oleraceæ** L., common purslane. *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch.
- Potentilla** sp., five-finger. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Pyrus arbutifolia** (L.) L. f., choke-cherry. *Frankliniella tritici* Fitch.
- Pyrus Malus** (L.) F. S. Gray, apple. *Hoplothrips major* Hood.
- Prunus** sp., wild cherry. *Chirothrips manicatus* Hal.; *Frankliniella tritici* Fitch.
- Raphanus raphanistrum** L., wild radish. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Hoplothrips leucanthemi* (Schränk); *Thrips tabaci* Lind.; *Thrips physapus* L.
- Rhus copallina** L., dwarf sumac. *Frankliniella tritici* Fitch; *Rhynchothrips usitatus* Hood; *Thrips tabaci* Lind.
- Robinia pseudoacacia** L., locust. *Frankliniella tritici* Fitch.
- Rosa** sp., wild rose. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Rudbeckia hirta** L., black-eyed Susan. *Frankliniella tritici* Fitch; *Limothrips cerealium* Hal.
- Rumex Acetosella** L., sheep sorrel. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Rumex crispus** L., curly dock. *Frankliniella tritici* Fitch.
- Rumex obtusifolius** L., bitter dock. *Chirothrips manicatus* Hal.; *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Sambucus canadensis** L., common elder. *Frankliniella tritici* Fitch; *Liothrips sambuci* Hood; *Thrips tabaci* Lind.
- Sericocarpus asteroides** (L.) BSP., white-topped aster. *Frankliniella tritici* Fitch; *Hoplothrips leucanthemi* (Schränk); *Thrips tabaci* Lind.
- Solidago** sp., goldenrod. *Frankliniella tritici* Fitch; *Hoplothrips subtilissimus* (Hal.); *Hoplothrips leucanthemi*

- (Schrank); *Thrips (Microcephalothrips) abdominalis* Crawford; *Thrips tabaci* Lind.
- Sphenopholis nitida** (Spreng.), grass. *Frankliniella tritici* Fitch.
- Symplocarpus foetidus** (L.) Nutt., skunk cabbage. *Ctenothrips bridwelli* Franklin.
- Taraxacum officinale** Weber, common dandelion. *Frankliniella tritici* Fitch; *Thrips physapus* L.
- Trifolium arvense** L., rabbit clover. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Haplothrips niger* (Osb.).
- Trifolium pratense** L., red clover. *Frankliniella tritici* Fitch; *Thrips tabaci* Lind.
- Trifolium repens** L., white clover. *Frankliniella fusca* (Hinds); *Frankliniella tritici* Fitch; *Haplothrips graminis* Hood; *Thrips tabaci* Lind.
- Verbascum Thapsus** L., common mullein. *Chirothrips manicatus* Hal.; *Elaphrothrips armatus* Hood; *Frankliniella tritici* Fitch; *Neoheegeria verbasci* (Osb.).
- Verbena** sp., verbena. *Frankliniella tritici* Fitch; *Haplothrips substillissimus* (Hal.); *Thrips tabaci* Lind.
- Vernonia noveboracensis** (L.) Willd., ironweed. *Frankliniella tritici* Fitch.
- Vicia Cracca** L., vetch. *Frankliniella tritici* Fitch.
- Yucca** sp., bear grass. *Bagnalliella yuccæ* (Hinds).
- Zea Mays** L., corn. *Frankliniella tritici* Fitch.

LIST OF THRIPS, LOCALITY, DATES OF COLLECTION,
AND HOST PLANTS

(Those species marked with an asterisk (*) are, as far as the writer knows, new to New York State.)

- Aeolothrips bicolor** Hinds. Babylon, July-Aug.; Dix Hills, July; Brightwaters, July. On *Agrostis alba*, *Betula nigra*, *Narcissus Pseudo-narcissus*, *Polygala lutea*, *Polygonum Persicaria*.
- Aeolothrips fasciatus** L. Babylon, June; Yaphank, Aug. On *Asclepias syriaca*, *Polygonum Persicaria*.
- Anaphothrips obscurus** Muller. Babylon, May-June; Westbury, July. On *Agrostis alba*; *Panicum* sp.

- Aptinothrips rufus** (Gmelin). Babylon, July; Westbury, July.
On *Agrostis alba*, *Panicum* sp., *Poa palustris*.
- ***Bagnalliella yuccæ** (Hinds) (det. Watson). Babylon, May-June. On *Yucca* sp.
- Bregmatothrips iridis** Watson. Brooklyn, Oct. (F. F. Smith).
On *Iris* sp.
- Chirothrips manicatus** Hal. Babylon, May-Sept.; Yaphank, Aug.; Westbury, July. On *Agrostis alba*; *Aster* sp.; *Digitaria sanguinalis*; *Erigeron ramosus*; *Gnaphalium sylvaticum*; *Narcissus Pseudo-narcissus*; *Panicum* sp.; *Plantago lanceolata*; *Poa palustris*; *Polygonum Persicaria*; *Portulaca oleracea*; *Prunus* sp.; *Rumex obtusifolius*; *Verbascum Thapsus*.
- Chirothrips obesus** Hinds. Babylon, Aug. On *Amaranthus retroflexus*.
- Ctenothrips bridwelli** Franklin. Babylon, June-Aug.; Huntington, Aug.; Islip, Aug. On *Arisæma triphyllum*; *Lilium canadense*; *Symplocarpus fœtidus*.
- ***Elaphrothrips armatus** Hood (det. Watson). Babylon, May.
On *Verbascum Thapsus*.
- Frankliniella fusca** (Hinds). Babylon, June-Sept.; Yaphank, June; Brightwaters, July. On *Agrostis alba*; *Anagallis arvensis*; *Chenopodium album*; *Chrysanthemum Leucanthemum*; *Convolvulus arvensis*; *Gladiolus*; *Hypericum* sp.; *Mollugo verticillata*; *Narcissus Pseudo-narcissus*; *Plantago lanceolata*; *Poa palustris*; *Polygala lutea*; *Polygonum aviculare*; *Polygonum Persicaria*; *Raphanus raphanistrum*; *Rumex obtusifolius*; *Trifolium arvense*; *Trifolium repens*.
- ***Frankliniella nervosa** (Uzel) (det. Watson). Yaphank, Aug.
On *Poa palustris*.
- Frankliniella tritici** Fitch. Babylon, Mar.-Sept.; Islip, July; Deer Park, Aug., Dix Hills, July; Huntington, Aug.; Brightwaters, July. On *Acalypha virginica*; *Achillea millefolium*; *Agropyron repens*; *Agrostis alba*; *Amaranthus retroflexus*; *Ambrosia elatior*; *Anagallis arvensis*; *Arctium minus*; *Arisæma triphyllum*; *Pyrus arbutifolia*; *Arrenatherum elatius*; *Asclepias syriaca*; *Asclepias tuberosa*; *Aster* sp.; *Azalea* sp.; *Berberis vulgaris*; *Betula nigra*; *Brassica campestris*; *Carya*

sp.; *Chenopodium album*; *Chrysanthemum Leucanthemum*; *Convolvulus arvensis*; *Coreopsis lanceolata*; *Daucus carota*; *Digitaria sanguinalis*; *Equisetum arvense*; *Erechtites hieracifolia*; *Erigeron canadensis*; *Erigeron ramosus*; *Eupatorium* sp.; *Fagopyron vulgare*; *Fragaria* sp.; *Galinsoga parviflora*; *Gladiolus*; *Gnaphalium sylvaticum*; *Habenaria blephariglottis*; *Hieracium aurantiacum*; *Hypericum* sp.; *Iris* sp.; *Lactuca canadensis*; *Lepidium virginicum*; *Leucothæa* sp.; *Lilium canadense*; *Linaria canadensis*; *Linaria vulgaris*; *Malva rotundifolia*; *Mollugo verticillata*; *Narcissus Pseudonarcissus*; *Oxalis stricta*; *Panicum* sp.; *Phleum pratense*; *Phlox* sp.; *Phytolacca decandra*; *Plantago lanceolata*; *Plantago Rugelii*; *Poa palustris*; *Polygonum Convolvulus*; *Polygonum Persicaria*; *Portulaca oleracea*; *Potentilla* sp.; *Prunus* sp.; *Raphanus raphanistrum*; *Rhus copallina*; *Robinia Pseudoacacia*; *Rosa* sp.; *Rudbeckia hirta*; *Rumex acetosella*; *Rumex crispus*; *Rumex obtusifolius*; *Sambucus canadensis*; *Sericocarpus asteroides*; *Solidago* sp.; *Sphenopholis nitida*; *Symplocarpus fœtidus*; *Taraxacum officinale*; *Trifolium arvense*; *Trifolium pratense*; *Trifolium repens*; *Verbascum Thapsus*; *Verbena* sp.; *Vernonia noveboracensis*; *Vicia Cracca*; *Zea Mays*.

***Frankliniella williamsi** Hood (det. Watson). Dix Hills, July.
On *Asclepias tuberosa*.

Haplothrips graminis Hood. Babylon, June. On *Trifolium repens*.

Haplothrips leucanthemi (Schränk). Babylon, May–July; Islip, July; Dix Hills, July; Brightwaters, July. On *Achillea millefolium*; *Chrysanthemum Leucanthemum*; *Erigeron ramosus*; *Hypericum* sp.; *Plantago lanceolata*; *Raphanus raphanistrum*; *Sericocarpus asteroides*; *Solidago* sp.

***Haplothrips niger** (Osb.) (det. Watson). Babylon, June–Aug.
On *Achillea millefolium*; *Chrysanthemum Leucanthemum*; *Erigeron ramosus*; *Plantago lanceolata*; *Trifolium arvense*.

***Haplothrips pergandei** Hinds (det. Watson). Babylon, Aug.
On *Agrostis alba*.

***Haplothrips subtilissimus** (Haliday) (det. Crawford). Babylon, Aug.–Sept. On *Aster* sp., *Berberis vulgaris*; *Convolvulus*

lus arvensis; *Lepidium virginicum*; *Phlox* sp.; *Solidago* sp.;
Verbena sp.

***Heterothrips azaleæ** Hood (det. Watson). Babylon, July.
On *Azalea* sp.

***Heterothrips lyoniæ** Hood (det. Watson). Babylon, July.
On *Azalea* sp.

Hoplothrips major (Hood). Babylon, July. Under bark of
dead apple tree.

Leptothrips mali (Fitch). Babylon, July; Brightwaters,
July; Westbury, July. On *Asclepias syriaca*; *Brassica*
campestris.

***Limothrips cerealium** Hal. (det. Watson). Babylon, July.
On *Asclepias syriaca*; *Fagopyron vulgare*; *Helenium* sp.,
Panicum sp., *Rudbeckia hirta*.

***Liothrips sambuci** Hood (det. Watson). Yaphank, Aug. On
Sambucus canadensis.

Neoheegeria verbasci (Osborne). Babylon, Jan.-July; Islip; Sept.
On *Verbascum Thapsus*.

Rhynchothrips usitatus Hood. Babylon, July; Islip, July;
Lindenhurst, July. On *Rhus copallina*.

Sericothrips cingulata Hood. Babylon. No data available.
Reported from Ithaca by Hood (May) in stomach of young
trout. A grass species.

Tæniothrips simplex Morison. Babylon, Feb. On *Gladiolus*
bulbs in storage during the entire winter. Collections from
foliage and flowers are represented from March to August.
The species is still a serious pest in this locality.

***Thrips (Microcephalothrips) abdominalis** Crawford (det.
Watson). Babylon, Sept. On *Solidago* sp.

Thrips nigropilosus Uzel. Babylon, June On *Ambrosia*
elator.

Thrips tabaci Lind. Babylon, April-Sept.; Deer Park, Aug.;
Huntington, Aug.; Dix Hills, July; Westbury, July; Yaphank,
August. On *Achillea millefolium*; *Amaranthus retroflexus*;
Ambrosia elator; *Arisæma triphyllum*; *Aster* sp.;
Berberis vulgaris; *Betula nigra*; *Brassica campestris*;
Chenopodium album; *Chrysanthemum Leucanthemum*; *Co-*
reopsis lanceolata; *Daucus carota*; *Digitaria sanguinalis*;

Erigeron canadensis; *Erigeron ramosus*; *Fagopyron vulgare*; *Galinsoga parviflora*; *Gnaphalium sylvaticum*; *Helenium* sp.; *Hypericum* sp.; *Lepidium virginicum*; *Linaria vulgaris*; *Narcissus Pseudo-narcissus*; *Panicum* sp.; *Plantago lanceolata*; *Poa palustris*; *Polygonum aviculare*; *Potentilla* sp.; *Raphanus raphanistrum*; *Rhus copallina*; *Rosa* sp.; *Rumex acetosella*; *Rumex obtusifolius*; *Sambucus canadensis*; *Sericocarpus asteroides*; *Solidago* sp.; *Trifolium pratense*; *Trifolium repens*; *Verbena* sp.

**Thrips physapus* L. (det. Crawford). Babylon, May–July, Sept. On *Raphanus raphanistrum*; *Taraxacum officinale*.

**Zygothrips harti* Hood. (det. Watson). Babylon, July. On *Helenium* sp.



PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF MARCH 15, 1938

A regular meeting of the New York Entomological Society was held on March 15, 1938, in Roosevelt Memorial; President Moore in the chair with about fifty members and visitors present.

Mr. Irvin Granek, of 367 Vernon Ave., Brooklyn, N. Y., was proposed for active membership.

The program committee reported that Dr. Melander would show some pictures of his recent trips to Florida at the next meeting.

Dr. Albert Hartzell, the speaker of the evening, then addressed the Society on "The Peach Yellows."

LUCY W. CLAUSEN, *Secretary*.

MEETING OF APRIL 5, 1938

A regular meeting of the New York Entomological Society was held on April 5, 1938, in Roosevelt Memorial; Vice-President Spieth in the chair with about thirty members and visitors present.

Mr. Irvin Granek was elected to active membership.

The program of the evening of notes by members was opened by Dr. Melander with colored moving pictures of his recent trip to Florida. A general discussion by members concluded the evening's meeting.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF APRIL 19, 1938

A regular meeting of the New York Entomological Society was held on April 19, 1938, in Roosevelt Memorial; President Moore in the chair with about thirty-five members and visitors present.

A meeting of the Executive Committee was scheduled for May 3 to discuss a letter from the Academy relative to contributions for mailing privileges enjoyed by the members of the New York Entomological Society.

Dr. Leonard called the attention of the Society to a testimonial dinner to be given in honor of Dr. E. O. Johannsen on April 30.

A motion was made and seconded that Dr. Moore write a congratulatory note prior to the 30th, upon the occasion of Dr. Johannsen's retirement.

Mr. William Trager, the speaker of the evening, then talked upon "Ticks and Disease Transmission" an abstract of which follows.

TICKS AND DISEASE TRANSMISSION

The life history of the common American dog tick, *Dermacentor variabilis*, was described as typical of the life cycle of most of the species of ixodid ticks. Since ticks transmit many diseases of man, and of domestic and wild animals, it was possible to consider in detail only three of these. Tularemia,

disease caused by bacteria, shows no intimate relationship between the causative organism and ticks. The disease can be transmitted by other arthropods and by direct contact. Ticks heavily infected with tularemia bacteria die as a result of the infection. Canine piroplasmosis, a protozoan disease, can be transmitted only by certain species of ticks. The protozoa undergo a definite developmental cycle in the tick, they do the tick no harm whatever, and they are hereditarily transmitted from one generation of ticks to another. Similar close relationships obtain between ticks and the rickettsiæ of Rocky Mountain spotted fever. The ticks responsible for the transmission of this disease are, in the western United States, *Dermacentor andersoni*, and, in the eastern United States, *Dermacentor variabilis*. In the tick host it is necessary to distinguish between the rickettsiæ of Rocky Mountain spotted fever, which very often occur intranuclearly, and the harmless rickettsiæ, found in certain ticks, which are intracellular but never intranuclear. All ticks of the species *D. variabilis* also contain so-called symbionts, coccoid bodies with a clear center which, in larvae and nymphs occur only in certain alimentary tract cells. In adults the coccoid bodies are found in all the alimentary tract cells and in the ovaries of the female. Besides transmitting various diseases, engorging female ticks produce directly two pathological conditions: (1) tick paralysis, due possibly to a neuro-toxin; (2) tick-host anemia, a secondary anemia due to loss of blood. It has recently been found that some animals develop a true acquired immunity against the larvæ of *D. variabilis*. This immunity lasts about 3 months.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF MAY 3, 1938

A regular meeting of the New York Entomological Society was held on May 3, 1938, in the American Museum of Natural History; President Moore in the chair with fifty members and visitors present.

A decision was made that the next and last meeting of the season would be in the nature of a farewell dinner to Mr. A. J. Mutchler.

The speaker of the evening, Dr. A. Glenn Richards, Jr., spoke upon "Some Aspects of Sterility in Insects," an abstract of which follows.

SOME ASPECTS OF STERILITY IN INSECTS

(Author's Abstract)

The concept of a *breeding unit* in nature has only partial validity because all degrees of isolation are found only some of which are based on or include sterility and because of the numerous exceptions to the idea of a breeding unit. Sterility was then defined as an inability to produce an indefinite number of generations of viable zygotes. Nevertheless there is a general broad parallelism of physiological affinity and morphological similarity and also a general correlation between degree of fertility and isolation.

One of the types of sterility is that of a vigorous soma for a sterile individual. This is the type that sometimes shows the phenomenon of hybrid vigor in a sterile individual. In some cases this sterility may be of a gross chromosomal nature but in insects at least the commoner form of sterility is genic in nature and due to a complex unbalanced genetic content of the viable zygote.

Examples were given from Stern's work on translocation stocks of *Drosophila melanogaster* which show various manifestations of hybrid sterility on outcrossing to normal stocks. It was pointed out, however, that these stocks could exist only in pure cultures and would soon be eliminated in mixed cultures or in nature.

Another of the examples given was that of the two physiological races of *Drosophila pseudoobscura* in which it has been shown by Dobzhansky that fertility of the males is dependent on the segregation into such individuals (obtained by backcrossing F_1 hybrid females to parental stock males) of all or almost all the chromosomes from one or the other of the two parental races, and that chromosomal pairing is not the direct cause of the failure of spermatogenesis.

These cases lead to questioning whether the germ cells are inherently incapable of normal development or whether there is some somatic deficiency that affects the development of the gonads. This question has been fairly well answered by transplants which show that gonads, both normal and sterile, undergo autonomous development in *Drosophila melanogaster* and *D. pseudoobscura*. The single exception is superfemale ovaries in normal hosts giving functional gametes which show non-disjunction and other abnormalities whereas superfemales themselves never produce functional gametes.

The question of a possible time effect and the transplants having been performed too late in ontogeny seem unlikely at least for *D. pseudoobscura* because primary spermatocytes are produced throughout pupal and much of larval life, the disruptive processes setting in at a later stage of spermatogenesis. It would seem that if a somatic effect on the gonads is to take place it would be effective also at relatively late stages in ontogeny since normal appearing spermatocytes are being produced then.

In summation it was concluded that these cases of sterility must be in the nature of complex unbalanced genetic constitution. This sounds like an obvious restatement of visible phenomena in nature but at least other possibilities have been eliminated. It follows that the evolutionary origin of sterility takes place in more than one step, and that sterility is not prerequisite for divergent evolution but a by-product of that evolution. This is also upheld by statistical analyses which show that too early cross sterility would stifle evolution by isolating too small parts of populations. The view that sterility is a by-product rather than a cause of speciation is really an advantage to taxonomists because it leaves all the old value of sterility and in addition shows how the intergrades and cases where sterility is lacking may be understood without listing as inexplicable exceptions.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF MAY 17, 1938

A regular meeting of the New York Entomological Society was held on May 17, 1938, in Hotel Franconia, 20 West 72nd Street, New York City, and a dinner testimonial was given in honor of Mr. A. J. Mutchler who was retiring from the Department of Entomology of the American Museum of Natural History.

Ninety members of the Society and friends of Mr. Mutchler attended. Mr. Mutchler was made a life member of the Society.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF OCTOBER 4, 1938

A regular meeting of the New York Entomological Society was held on October 4, 1938, in the American Museum of Natural History; President Moore in the chair with fifty members and visitors present.

The meeting was of a social nature with refreshments.

The following were proposed for active membership: Miss Annette Bacon, American Museum of Natural History; Miss Alice Gray, American Museum

of Natural History; Mr. F. Snyder, John Powell Co., New York City; Dr. D. L. Collins, Cornell University, Ithaca, N. Y.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF OCTOBER 18, 1938

A regular meeting of the New York Entomological Society was held on October 18, 1938, in the American Museum of Natural History; President Moore in the chair with forty members and visitors present.

The program committee reported that at the Nov. 1 meeting there would be a discussion of notes by members on their summer collecting.

The following were elected to active membership: Miss A. Bacon, Miss A. Gray, Mr. F. Snyder, Dr. D. L. Collins.

Mr. Fred Snyder, the speaker of the evening, talked upon "Some Unusual Habits of Some Muscid Flies" an abstract of which follows.

A brief statement regarding the small number of species of flies in which the life histories are known was made.

This was followed by a discussion of the limits of the family and how phylogeny does not necessarily correspond to the progressive development of the parasitic habit from the coprophagous habit or *vice versa*.

This progression was divided into two parts, the plant progression and the animal progression. The steps in these two types were traced, various species being used as examples. Particular emphasis was placed upon the development of very limited environments, *e.g.*, birds' nests, and specific host-relationships.

Viviparity was discussed in relation to certain coprophagous muscids, and the progressive steps in the development of this habit from first instar larvæ to late fourth instar production was traced by means of certain examples.

Morphological peculiarities which particularly aid the various species in their life economy were given as were certain remarkable adult habits and especially the interesting type of hibernation which *Pyrellia serena* (Meigen) undergoes.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF NOVEMBER 1, 1938

A regular meeting of the New York Entomological Society was held on November 1, 1938, in the American Museum of Natural History; President Moore in the chair with 25 members and visitors present.

Mr. Joseph Rosenblum, 1330 Washington Ave., New York City, was proposed for active membership.

The program committee announced that Mr. Donohoe of Trenton, N. J., would speak on "Insects Found in Raisin Storages."

The meeting was then given over to members for a general discussion of field notes. Mr. W. T. Davis exhibited several boxes of specimens of cicadas and cicada killers and told of two colonies on Staten Island. According to him it is not the song of the cicada that the cicada-killer uses to locate her prey but rather her ability to quickly sense any movement of her prey.

Mr. Engelhardt exhibited a specimen of the papaya fly, *Toxotrypan curvicauda*, given to him by the owner of a papaya farm at Dayton, Florida. These insects once established are troublesome pests. The females, by means

of a long ovipositor, puncture the ripening fruit and the maggots, penetrating to the seed centers, render the fruit unpalatable. The much smaller males, according to the farmer, are not often seen and are very hard to capture.

Mr. Moennich brought some fungoid Coleoptera and talked of his experiences in collecting them.

Dr. Fox spoke of his studies upon the mantis *Ptenodera*—the average number of eggs per capsule and of the parasites of it.

Mr. Jones proudly passed for inspection a hermaphroditic specimen of the Gypsy Moth—male and female markings showing very clearly.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF NOVEMBER 15, 1938

A regular meeting of the New York Entomological Society was held on November 15, 1938, in the American Museum of Natural History; President Moore in the chair with thirty members and visitors present.

Mr. Joseph Rosenblum was elected to active membership.

The speaker of the evening, Mr. Donohoe, spoke of "Some Insects Associated with Raisin Storages."

LUCY W. CLAUSEN, *Secretary*.

MEETING OF DECEMBER 6, 1938

A regular meeting of the New York Entomological Society was held on Tuesday, December 6, 1938, in the American Museum of Natural History; President Moore in the chair with two hundred and forty members and visitors present.

Due to the large number of visitors present the reading of the minutes of the preceding meeting as well as other business was suspended.

Dr. Melander, the speaker of the evening, showed his colored motion pictures of "Who's Who among the Insects, 1938." The pictures were without doubt the best ever done in the field.

At the next meeting of the Society on December 20, 1938, Mr. F. S. Blanton was scheduled to speak on "Some Insects Affecting Narcissus and Some Methods of Control."

Mr. August Schmitt, of 389 East 151st Street, New York City, was proposed for active membership.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF DECEMBER 20, 1938

A regular meeting of the New York Entomological Society was held on Tuesday, December 20, 1938, in the American Museum of Natural History; President Moore in the chair with twenty members and visitors present.

The President appointed a nominating committee of Dr. C. H. Curran, Mr. John D. Sherman, Jr., and Mr. E. L. Bell.

Mr. August Schmitt was elected to active membership.

The following were proposed for active membership: Arthur Davidoff, 725 West 172nd Street, New York City; Morris Gadol, 972 Tiffany Street, Bronx, New York City; James W. Johnston, Jr., 106 East 236th Street, New York City.

The address of the evening on "Insects Affecting Narcissus and Some Methods of Control" was delivered by Mr. F. S. Blanton. Mr. Blanton explained the method of growing narcissus for commercial purposes and pointed out how this affected control measures of the several pests. The two chief pests discussed were the bulb fly, *Merodon equestris*, and nematodes. Considerable discussion followed the address.

C. H. CURRAN, *Acting Secretary*.



BOOK NOTICES

Marvels of Insect Life: A Popular Account of Structure and Habit. Edited by Edward Step. Intro. by Raymond L. Ditmars. Square 8vo., cloth, 486 pp., 640 illus., N. Y., Robert McBride & Co., 1938. \$3.75.

This is a new edition of a previously published popular presentation of common, well known facts—and fancies—regarding equally common and well known insects. A page by page comparison made by this reviewer of this latest with the former, apparently first, edition, published in 1915 by Hutchinson in London, reveals that the original very fine half tone text illustrations have been replaced by photographic reproductions, many of which are even better than those formerly used. The twelve colored plates which appeared in the first edition have been omitted, with the exception of those opposite pages 200 and 240, in which instances photographic reproductions of other subjects have been substituted for the color work. There appears to have been no change whatever in the original text, with the exception of the addition of three pages of appreciative introductory matter prepared by Dr. Ditmars. The arrangement of the subject matter entirely disregards order, family, or genus, but, instead, is so highly heterogenous as to lead its readers to wonder if it may have been placed in its present hit or miss sequence by sheer chance rather than by any orderly plan. The index, however, has been so carefully prepared and is so very thorough and complete that the lack of orderly arrangement of the text does not detract from the usability of the book and renders such lack practically unnoticed by most readers. If one may judge from the positively lavish output on part of various publishers at the present time, there verily must be an active steady demand by the reading public for scientific information administered in sugar-coated doses such as this. Indeed, there has been in just recent months such a plethora of books of this general type that possibly there might be no real excuse for giving space here to notice of another one except for the fact that the particular book now under consideration is

especially meritorious in that particular emphasis has been placed on insect photography by amateurs, and there has been provided a large number of unusually excellent examples for the emulation and the envy—and possibly the despair—of the amateur photographer, and this feature alone probably will render the book an outstanding one of its kind and will greatly augment its demand.—J. S. W.

The Garden Dictionary, an Encyclopedia of Practical Horticulture, Garden Management and Landscape Design. Edited by Norman Taylor. Quarto, cloth, 888 pp., numerous illustrations, 20 plates in full color, map, Boston, Mass., Houghton, 1938. \$7.50.

The scope of this notice is limited to discussion of only such of the various subdivisions of the subject matter of the above work as are of entomological interest. In preliminary to this, it should be stated that it has been the principal objective of the Editor and the 68 specialists who have contributed to this composite work to produce a reference book that would possess a permanent value and would be as nearly as possible indispensable to all gardeners. The guiding principle throughout has been expert knowledge and advice translated into the simplest possible terms. It was suggested to the specialist-contributor that: "Your article must not be written for the experts, but it must be apparent that it has been written by one." The compilation represents several years of work and the hearty cooperation of many individuals and institutions. It has been so planned as to be an index to itself, so simply arranged as to render it easy to find desired data with a minimum of groping among momentarily useless features. Thousands of cross word items have been inserted to lead one directly to the needed information, and over 4,400 common and vernacular names are similarly cross-referenced to the articles where their culture is discussed. No word of special import has been used unless that word is defined at its proper vocabulary entry, thus obviating necessity for use of other reference works to understand the terms used in this one. Since the contents of the book are arranged in strictly dictionary form, it is obvious that the principal sections dealing with entomological subjects are to be found under such

division headings or catch words as would be most likely to be considered and used. In harmony with this plan there are 4 articles of approximately 2,000 to 4,000 words each on Insect pests and their control, Insecticides, Fumigation, Spraying and dusting. Also, there are 3 shorter articles of about 300 words each on Ants, Earthworms, and Insect friends. There are likewise over 130 shorter articles of 10 to 400 words each dealing individually with insect pests of principal horticultural plants and their control, these being incorporated in the articles pertaining to the various host plants. All the entomological material was compiled by Dr. F. M. Wadley, now of the United States Bureau of Entomology and Plant Quarantine. In conformity with the general plan of the book, this material has been reduced to the shortest possible length consistent with clearness and practical usefulness. Special emphasis has been placed on non-technical descriptions of the given insect and the character of its injury and on the most efficient control measures. Due attention also has been given to recommended farm practices, to quarantines, and to other matters for which consideration is necessary in biological and other control of insect pests. Brief summaries are included for the preparation and use of all the more common insecticides, not forgetting mention of a number of those more recently under experimental consideration. Since the object of this Dictionary is to give its readers instant access to clear, concise, accurate information, with complete descriptions and details on exactly how to grow all the commonly cultivated plants in this country, flowers, fruits, vegetables, shrubs, trees and vines, it is believed that the book will have a wide practical usefulness.—J. S. W.

THOMAS SAY'S HOME IN NEW HARMONY

In "Thomas Say, Early American Naturalist" (1931), there are two illustrations of houses in which Thomas Say was thought to have lived. One, entitled "A House in which Thomas Say lived, in New Harmony, Indiana," is after F. M. Webster (*Ent. News*, vol. vi, 1895) and the other, entitled "Rappite House No. 5, New Harmony, Indiana, said to have been the home of Say in 1829-1830," was supplied by Dr. Charles P. Alexander and Professor J. Speed Rogers.

During February, 1938, I received from Miss M. E. Fauntleroy, of New Harmony, Indiana, a letter calling my attention to the illustration of Thomas Say's residence in New Harmony, a typical Rappite house, in George B. Lockwood's "New Harmony Communities," and advising me that this was Rappite house No. 53 and that it should be considered as the home of Mr. and Mrs. Thomas Say. Miss Fauntleroy's aunt, who lived to be ninety-four, and who knew Mrs. Say, recalled that the Says had moved from No. 53 into Maclure's home, which burned down in 1844. Number 53 was built in 1815 by the Rappites, and purchased and remodeled in 1841 by Robert Henry Fauntleroy. It is now the property of the Indiana Federation of Clubs and is known as The Old Fauntleroy Home and as the former dwelling place of many distinguished persons. It is located at the southwest corner of Granary and West Streets.

Although Victor Duclos, a passenger on the Boat-load of Knowledge and a friend of Miss Fauntleroy's father, mentions in his diary that he went to see Mr. Say at his home on the northwest corner of Granary and West Streets, Miss Fauntleroy states that this diary was dictated and that a mistake in corners could easily have been made and that other mistakes occur. It is her belief that Mr. Say may have lived there before his marriage, but that after his marriage he moved to Number 53, now known as the Old Fauntleroy Home. Later he lived in Number 5, the old home of George Rapp, and of Maclure, which was destroyed by fire in 1844. It was in Number 5 that he died.—H. B. W.

The New York Entomological Society

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Certificate of Incorporation expires June 7, 1943

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

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JUNE, 1939

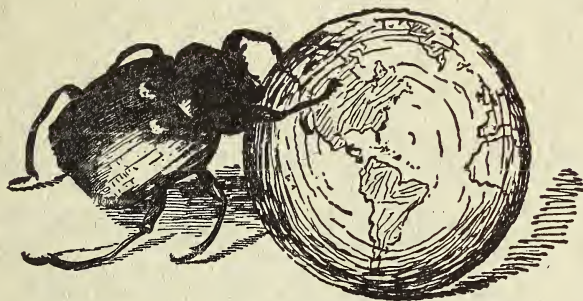
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New York Entomological Society



Devoted to Entomology in General



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No. 2

THE PROBABLE FUTURE DISTRIBUTION OF THE JAPANESE BEETLE IN NORTH AMERICA

BY HENRY FOX

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NEW YORK UNIVERSITY¹

INTRODUCTION

The Japanese beetle, *Popillia japonica* Newman, is now known to be present in this country at numerous localities extending from

¹ The studies upon which this paper is based were begun unofficially early in the period of employment of the writer as Associate Entomologist, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. It was only for a relatively short period toward the end of his connection with the Bureau that the subject was specifically recognized as an official project of investigation. Following the writer's detachment from the Bureau the same line of studies was continued independently at New York University and the results to date are here presented as a contribution from the Department of Biology of that institution.

Some of the conclusions reached in this study were published in advance by C. H. Hadley (Jour. N. Y. Ent. Soc. XLVI: 203-216, 1938). One paragraph in his article on the ultimate distribution of the beetle (p. 203-204) is an almost verbatim transcript of a summary furnished Mr. Hadley at his request. In the article as published, customary acknowledgment of the source of the information was withheld.

Editor's Note: Under date of December 1, 1938, I was advised by Dr. Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, that Mr. Hadley's manuscript was submitted to the Bureau for approval on December 12, 1935, and that it included a reference to an unpublished "report" by Doctor Fox, which summarized studies carried on by him up to that time as an employee of the Bureau, as well as references to other unpublished reports. In accordance with the general practice of the Editorial Office of the Bureau, these citations were deleted.

JUN 10 1939

south-central Maine and north-central New York south to northern South Carolina and west as far as Detroit, Michigan, Chicago, Illinois, and St. Louis, Missouri. Since the insect has maintained itself for the past five or six years in such outlying points of its apparent range as Brewer, Maine, Greenville, South Carolina, and St. Louis, Missouri, its establishment is likely to be permanent in most, if not all, the localities from which it has been hitherto reported, unless checked by artificial means. Although in the vastly greater part of the area, whose limits are approximately defined by the localities cited, the Japanese beetle occurs only in the form of local colonies more or less widely separated from one another and from the present main distribution area of the species in New Jersey and neighboring states, there can exist little doubt that eventually the intervening country will be occupied as a result of the meeting and coalescence of the various local areas of dispersal originating in and progressively expanding about these centers.

The apparently permanent establishment of the beetle at numerous points distributed throughout an area embracing the greater part of the eastern third of the United States obviously points to the existence within that section of environmental conditions to which it is generally adapted. This view is in accord with the known reactions of the Japanese beetle to temperature and humidity and is also substantiated by a comparison of the climate of this country with that of Japan, which shows that the latter is most nearly duplicated in those parts of the United States where the Japanese beetle is now present.

In insects which, like the Japanese beetle, pass the greater part of their annual life-cycle beneath the surface, the more obvious environmental factors conditioning their distribution are, apart from oceanic barriers, temperature and precipitation. While these as generally recorded are atmospheric phenomena, they produce effects underground which are closely correlated with the changes occurring above the surface.

TEMPERATURE RELATIONS OF THE BEETLE

The studies of Ludwig (1928, A) have shown that the effective range of temperature for development in the Japanese beetle extends from about 12° C. (53.6° F.) to 35° C. (95.0° F.). How-

ever, the insect appears to be capable of passing through the complete life-cycle only at temperatures ranging between 17.5° C. (63.5° F.) and 27.5° C. (81.5° F.). The reason is that a temperature which may be suitable for certain developmental processes may be prohibitive to others essential to carry the insect through the complete life-cycle.²

The temperature of the air necessarily influences that of the ground, especially near the surface where the daily fluctuations conform to the same general pattern, except for a marked decrease in total range due to the lag in change of temperature arising from the poor conductivity of the soil. Where the plant cover does not preclude penetration of the direct rays of the sun, part of the rise of temperature in the immediately underlying layers of the soil results from their absorption. Hence, throughout most of the season of Japanese beetle activity and reproduction the daily rise of temperature in the soil at the shallow depths occupied by the insect more nearly approaches that attained in the air than does the fall of temperature during the night. During this period the temperature of the soil in such situations thus averages from one to several degrees higher than that of the air as computed from the readings of the ordinary air-exposed thermometer. Accordingly, when the usually recorded seasonal mean temperature of a given station is taken as an index of its suitability for Japanese beetle growth and development, it needs to be kept in mind that the mean temperature to which the insect is exposed is likely to be a degree

² The present writer has found that eggs of the Japanese beetle kept at a constant temperature of 54° F. (12.2° C.) undergo some development, but fail to hatch. However, other eggs which had passed through the greater part of their development at higher temperatures (approximately 75° F.) readily hatched when placed at 54° F. But the larvae hatched at this temperature invariably died within a few days unless transferred to a higher temperature, probably because at 54° F. the larvae are too sluggish to feed. At the opposite extreme, Ludwig found that when the larvae are reared throughout at a temperature of 27.5° C. (81.5° F.) only a few reached the adult stage, the others for the most part dying during the period of metamorphosis of the larva into the pupa, a result which the present writer has confirmed. On the other hand, larvae which had passed through part of their larval development under outdoor conditions, at temperatures averaging between 65° and 75° F., completed the remainder of their development and passed through the metamorphosis without evident difficulty when kept at a nearly constant temperature of 27.5° C. (Fox, Ms.)

or two higher than the recorded temperature. This is shown by records kept for the past 10 years at Moorestown, N. J., where a mean temperature in mid-summer of approximately 74.5° F. is correlated with a mean of about 77.0° F. (25° C.) at a depth of one inch in ground covered with sod, as in the usual habitat of the Japanese beetle larva.

INFLUENCE OF SOIL MOISTURE ON SUMMER SURVIVAL

Atmospheric precipitation naturally conditions the moisture content of the soil where the greater part of the life-cycle of the Japanese beetle is passed. The dependence of the insect upon such moisture is evidenced by the annual fluctuations in its abundance as observed in its main distribution area in this country. Greatly reduced populations have been invariably correlated with a marked deficiency in rainfall during the preceding summer. The normal rainfall for the entire summer in the area in question amounts roughly to 12 inches, which, while somewhat less than in the corresponding temperature zone of Japan, appears to be sufficient to meet the moisture requirements of all stages of the Japanese beetle present at the time. However, during the period covered by the writer's observations on beetle abundance, there occurred two summers (1929, 1932) in which the rainfall in the vicinity of Philadelphia was markedly deficient, falling from 4 to 6 inches below the normal. In each case this deficiency in rainfall during the summer was followed by a Japanese beetle population much reduced below that represented in other years when more nearly normal rainfall conditions prevailed during the summers.

The reason for such striking reductions in Japanese beetle populations in connection with summer drought is doubtless to be found in the fact that summer is the season of maximum egg deposition and hatching for the insect. It is during these initial stages in its annual life-cycle that moisture, in a readily available form, is most urgently needed and its absence or scarcity most likely to prove fatal. The egg, like that of other scarabæid beetles, must absorb moisture to bring about the swelling which is the essential prelude to embryonic development, while the newly hatched larva needs it to retard desiccation until it succeeds in finding some source of food succulent enough to supply it with the needed

moisture as well. Ludwig (1936), who has studied the desiccation of the Japanese beetle, states that the larva in each of its three instars can withstand a loss of body moisture equal to half its initial body weight. Further loss is fatal. In freshly hatched larvæ the actual amount of moisture lost before the fatal limit is reached would evidently be much less than in older larvæ, and hence the time required to effect desiccation correspondingly shortened. In such larvæ the surface is only very lightly chitinized and hence conserves body moisture much less effectively than in later stages when it is more heavily chitinized. Moreover the freshly hatched larva, on account of its minute size and the soft consistency of its body, can burrow only very slowly through the soil in its search for food. For these various reasons, it would seem obvious that any marked lack of moisture in the immediate surroundings would prove far more detrimental to the insect during the period of egg development and hatching than at any other period during its annual life-cycle.

Since both the egg and larva of the Japanese beetle occur in the ground, the moisture which more directly affects them is that of the surrounding soil. This is primarily conditioned by the amount and distribution of the rainfall, but is also influenced by other factors, such as the topographic situation and the texture and composition of the soil. On this account the Japanese beetle is often enabled to survive in considerable numbers in circumscribed areas where, because of sluggish drainage, moisture in the soil is retained much longer during a prolonged drought than in other parts of the affected area.

INFLUENCE OF PRECIPITATION ON WINTER SURVIVAL

Atmospheric precipitation indirectly affects the temperature of the soil. In moist ground the change in temperature in response to fluctuations in atmospheric temperature is slower than in dryer soils. Hence in a humid region sudden or extreme changes in the temperature of the air produce relatively slight changes beneath the surface, where the temperature tends to fluctuate only a relatively few degrees on either side of the seasonal mean. But the most important effect of precipitation on the temperature of the soil from the point of view of insect survival is to be found in

winter, when, as Mail (1930) has demonstrated, the blanket of snow serves to keep the temperature of the subjacent soil within a few degrees of the freezing point (0° C.; 32° F.), even during prolonged periods of intense cold, which otherwise would prove fatal to the insects present in the ground.

In connection with this latter effect, the capacity of the Japanese beetle larva to withstand cold is important, the larva being the stage in which the insect passes the winter. Data from several sources, including some recent unpublished observations by the writer, point to $+15^{\circ}$ F. (-9.4° C.) as the lowest temperature which the larva could withstand under natural conditions. Air temperatures in winter, in most of the areas at present occupied by the Japanese beetle, frequently range far below this lethal point and the fact that notwithstanding the insect has survived in undiminished strength is attributable to the protective covering of snow which kept the temperature of its subterranean habitat well within the limits of cold tolerance of the larva.³

TYPE OF COUNTRY FAVORABLE FOR THE BEETLE

The foregoing facts indicate the adaptation of the Japanese beetle to a country having (1) a range of temperature capable in the summer of maintaining the mean temperature of the soil within limits (17.5° – 27.5° C.) favorable for the hatching of the eggs and the survival of the early larvæ, and (2) a precipitation copious in amount and rather uniformly distributed throughout the year, thereby in summer furnishing the soil moisture needed to prevent desiccation of the eggs and freshly hatched larvæ, and in winter providing the protective covering of snow serving to keep the temperature of the ground within the limits of cold tolerance of the larvæ.

CLIMATE AS A POSSIBLE LIMITING FACTOR IN JAPAN

These conditions are admirably fulfilled in the original home of the beetle in Japan, where its range, with the possible exception of a narrow belt along the extreme northern and northeastern coast of the northernmost island, Hokkaido, appears to be coextensive

³ At Moorestown, N. J., during the excessively cold winter of 1934 at the same time that the minimum for the season of -13° F. was recorded, the temperature in the soil at a depth of only 1 inch below the surface was $+27^{\circ}$ F., within 5 degrees of the freezing point.

with the entire archipelago of four large islands which constitute Japan in the usual restricted meaning of the term.⁴ Within these limits, the mean temperature of the summer is reported as ranging from 13.6° C. (56.5° F.) at the extreme eastern tip of Hokkaido (Nemuro) to 25.0° C. (77.0° F.) near the southern extremity of the country (Kagoshima). But within the portion in which the beetle is definitely known to occur, the lowest mean reported for the summer is 17.1° C. (62.6° F.). If means lower than the latter be disregarded, the range of summer temperatures in Japan points to the general prevalence in the soil (sod land) of that country of summer means falling within the postulated limits (17.5°–27.5° C.) for normal development of the beetle. As regards precipitation, Japan is reputed one of the wettest countries in the world, the rainfall often being extremely heavy and usually well distributed throughout the year. In winter snowfall is stated to be scanty in the southern half of the country, but very heavy in the extreme north where it presumably enables the beetle to survive such severe winters as prevail in the interior of Hokkaido (Asahigawa) where a temperature as low as –41° C. (–41.8° F.) has been reported.

If the Japanese beetle is indeed absent in that section of Hokkaido, as about Nemuro and elsewhere along the northeast coast of that island, from which there are no definite records of its occurrence, it follows that, if climate is alone involved, the limiting factor in its northward range in Japan is the low temperature of the summer rather than the cold of winter. The beetle is reported as common and generally distributed in the interior of Hokkaido

⁴ For detailed data on the occurrence of the beetle in Japan the writer is indebted to J. L. King, T. R. Gardner, and L. B. Parker. Their scouting records indicate its general prevalence throughout the three southern islands and in most of Hokkaido, but leave unsettled its status in the more outlying northern and northeastern sections of the latter, where their scouting, as at Nemuro and other nearby localities yielded only negative results. It is possible that the absence, or at least marked scarcity, of the insect in this section of Hokkaido may be due to the fact that it is only in this highly restricted part of Japan that the temperature during the summer averages below the lowest limit (17.5° C.) favorable for the development of the eggs and early larvæ. However, as Gardner has suggested to the writer, it may be that the heavily forested state of the country adjoining Nemuro and other nearby towns is also responsible for the local scarcity of the beetle.

where the winters are most severe, while it is absent or scarce in a section where, because of the low altitude and the proximity of the ocean, the temperature in winter is considerably milder, but where in summer it averages lower than in any other part of Japan.

How effective high temperatures are likely to prove in limiting the southward range of the Japanese beetle is a problem upon which a knowledge of its distribution in its native country sheds no light, the obvious barrier to its spread in that direction being the ocean rather than any climatic condition. In experiments no beetles have been reared through the complete life-cycle when constantly exposed to a temperature above 27.5° C., but in nature constant temperatures are highly exceptional and Japanese beetles reared under variable temperatures have been found to withstand exposure to higher temperatures more successfully than those retained throughout their life at such temperatures.⁵

SECTION OF NORTH AMERICA FAVORABLE TO THE BEETLE

Since a country with the climatic features of Japan is indicated by the evidence at hand as preeminently suitable for the Japanese beetle, it is likely that the insect will find conditions most favorable to its permanent establishment in those parts of this continent where the climate in its totality most nearly duplicates that of Japan. In a general sense, this is the case in all that portion of the United States and southern Canada which lies east of the 100th Meridian; in other words, in what is known as the Humid Belt of North America. It is in this portion of the continent that, along with an annual range of temperature similar in general to that of Japan, precipitation is normally both copious in amount and rather generally and uniformly distributed throughout the year. Farther west the country is either too dry at all times, or else during certain critical periods in the year, to offer any general climatic conditions comparable with those of Japan.

RAINFALL AS THE MAJOR LIMITING FACTOR IN THIS COUNTRY

The probability that rainfall will prove a potent factor in limiting the future range of the Japanese beetle in this country is in a measure substantiated by the fact earlier mentioned that greatly reduced populations of the insect have been invariably observed

⁵ See footnote 2.

following summers with a marked deficiency in rainfall. In general, it would seem that a total rainfall for the summer of less than 10 inches is likely to prove detrimental to the species. It, therefore, seems safe to infer that it would find conditions strongly adverse to its permanent establishment in those portions of this country where, as in the western interior, an arid or semi-arid climate is the rule, or where, as on the Pacific Coast, the summers are generally rainless.⁶

Although the entire eastern half, or Humid Belt, of the United States exhibits climatic conditions in fairly close agreement with those of Japan, it deviates from the latter in several ways, notably in its more variable rainfall. In Japan the rainfall appears to be almost invariably copious at all times during the year, with relatively little variation in its quantity from year to year. Droughts, except in very restricted areas, are said to be practically unknown. In the United States, on the other hand, droughts at irregular, though rather frequent, intervals form a characteristic feature of the climate, even in its normally well-watered eastern sections. Hence, the probability of the occurrence of protracted droughts during the summers, with their more or less detrimental effects upon Japanese beetle populations, is considerably greater in this country than in the original home of the beetle in Japan. Such droughts naturally tend to increase in frequency and severity in sections where the rainfall is normally lighter, as in parts of the central Mississippi valley, where the rainfall in summer averages from two to four inches less than in the states adjoining the North Atlantic coast. It accordingly seems probable that the Japanese beetle will find rainfall conditions in the central Mississippi basin and other east-central sections of this country somewhat less favorable than in its present main distribution area near the eastern seaboard.

Despite the potential danger to Japanese beetle survival arising from the relative frequency of protracted droughts during the summers, it is questionable if there is any part of the eastern half of this country in which elimination of the insect from this source

⁶ This remark would not necessarily apply in local instances where, as a result of artificial irrigation, conditions typical of the region have been radically altered.

would be more than transitory. Observations in the Philadelphia area have shown a marked predilection of the beetle during dry seasons to select low-lying, sluggishly drained tracts in which to deposit its eggs. In such situations, owing to the proximity of the water-table to the surface and seepage from the surrounding higher ground, the soil is likely to retain a moisture content favorable to the insect for a much longer period than elsewhere in the vicinity. This habit obviously favors its survival in a drought-stricken district. Such observations suggest that to effect a reduction in the numbers of the beetle to the point of extermination a drought would have to be sufficiently prolonged to bring about a cessation of flow in all except the major streams of a district. While this has happened repeatedly in various parts of the eastern half of the United States, it is only very rarely that droughts of such severity extend simultaneously over more than a limited area. Hence, even if in a given area a drought would effect the elimination of the insect, it would not be long before it would be again populated because of the survival of the beetle in some adjoining area where the rainfall was more nearly normal.⁷ Hence the chance of droughts serving to eliminate the Japanese beetle throughout any considerable part of the eastern half of the United States would seem to be very slight. About all that can be expected is that the greater frequency of prolonged summer droughts in much of the central Mississippi basin would tend to keep its Japanese beetle populations reduced to more moderate numbers than in the more humid sections of the country bordering the Atlantic coast.

WINTER CLIMATE AS A POSSIBLE LIMITING FACTOR IN THE NORTHWARD SPREAD OF THE BEETLE

Although it is highly questionable whether droughts in summer are likely to have more than a local, or at most moderately reduc-

⁷ A perusal of the detailed data on precipitation published in the Climatic Summary of the United States by Sections shows that in practically all of the country lying east of the 100th Meridian summer droughts of exceptional severity practically never extend simultaneously over more than a limited area. Even a drought as widespread as that of the summer of 1930, although rather general over most of the East, was far from being universal, the continuity of the several drought areas being more or less extensively interrupted by belts of more nearly normal precipitation intercalated between them.

ing, effect upon Japanese beetle abundance throughout the normally well-watered eastern half of this country, there exists one section in which there is reason to believe that the normally light precipitation in winter may interact with the temperature to produce a condition prohibitive to the permanent survival of the insect. This is the region lying west of, and in the same general latitude as, the Great Lakes and extending thence to the Missouri River. In this section, which is usually termed the Northern Interior, occur the most severe winters within the limits of the continental United States. It comprises the entire state of Minnesota along with much of Wisconsin and of North and South Dakota and the northern half of Iowa. Within the limits thus roughly defined, the temperatures normal to the winter fall definitely below the lowest normals for the same season recorded from Japan, although the differences in absolute minima (-43° F. and -42° F.) are not impressive.

The relatively light winter precipitation of this section, averaging less than 4 inches, increases the chance of a prolonged period of sub-freezing temperature coinciding with an absence of snow. The larva of the Japanese beetle can be killed by lowering the temperature of the ground, at the depths occupied by it in winter, to the lethal point, which as earlier stated, appears to be approximately $+15^{\circ}$ F. As Mail (1930) has shown, it is only when snow is absent that intense cold is capable of lowering the temperature of the soil more than a few degrees below the freezing point. This condition was actually realized in the course of the particular winter during which Mail's observations were made at Minneapolis. A mid-winter thaw, resulting from a "warm wave," caused whatever snow had been present to vanish and this was succeeded by a "cold wave," with daily temperatures for nearly a month almost uninterruptedly averaging below $+20^{\circ}$ F. As a result, refrigeration of the soil progressed until a temperature of $+15^{\circ}$ F. was reached at all depths as far down as a foot below the surface. Since in their usual habitats Japanese beetle larvæ do not winter at greater depths, it follows that a similar refrigeration of the soil in a place where they chanced to be present would result in their practical, if not complete, extermination.

A winter climate comparable in severity with that of the Minneapolis district and characterized by an equally light precipitation

prevails generally as far south as southwestern Wisconsin, central Iowa and northeastern Nebraska. If present views as to the cold tolerance of Japanese beetle larvæ are sound, and if a similarity of general climatic conditions may be taken as an index of the occasional coincidence of the low temperatures normal to the region with a general absence of snow, it would seem that in the northern interior of this country any permanent extension of range of the Japanese beetle north of the latitude of central Iowa is precluded.

In the region of the Great Lakes and thence east to the Atlantic Ocean the precipitation in winter is normally so copious as to make highly improbable the coincidence of a prolonged period of intense cold with the absence of a snow cover. Furthermore, in correlation with the increased humidity which is thus implied, the temperature in winter of this more eastern section of the country averages considerably higher than in the northern interior, making all the more improbable the occurrence within its limits of any combination of circumstances likely to seriously militate against the spread of the Japanese beetle throughout New England, New York and the Lower Peninsula of Michigan, as well as across the border into the adjoining provinces of Canada.

SUMMER TEMPERATURE AS A LIMITING FACTOR IN THE NORTHWARD SPREAD OF THE BEETLE IN THE EAST

In all parts of this country where precipitation throughout the year is normally copious, the effective barrier to the northward spread of the Japanese beetle is less likely to be the severity of the winters than the low temperatures of the summers, which in the more northern portions would either inhibit the hatching of the eggs or prevent the survival of the young larvæ. Within the United States the northward limits of spread of the beetle in the East will probably fall near Eastport, Maine, with a temperature in summer almost identical with that of Nemuro, Japan, in the more elevated sections of northern New England and New York, and in extreme northern Michigan. Elsewhere the beetle is likely to extend its range across the border into the adjoining sections of Canada, as far along the St. Lawrence as Montreal at least and in the interior to Georgian Bay.⁸

⁸ According to data obtained by Ludwig, eggs of the Japanese beetle kept at a constant temperature of 17.5° C. (63.5° F.) take from 31 to 37 days to

SUMMER TEMPERATURE AS A LIMITING FACTOR TO THE ESTABLISHMENT OF THE BEETLE IN THE WEST

Rainfall in summer on the crests of the higher mountain ranges of the West, as the Rockies and the Cascades, would doubtless be sufficient to furnish the soil moisture needed by the Japanese beetle in its early stages, but the low temperatures of the summers at such altitudes would probably preclude its establishment. Along the Sierra Nevada the moisture stored in the ground from the melting of the heavy snowfall of the winters would favor the beetle, but, as in the other cases mentioned, the cold summers would probably be prohibitive to its survival.

Essentially similar conditions would presumably make difficult the establishment of the beetle along the more northern sections of the Pacific Coast, as in Oregon, Washington and Vancouver, where the rainfall in summer, while generally scanty, is heavier than farther south.

THE PROBLEM OF THE FUTURE SOUTHWARD SPREAD OF THE BEETLE IN THE EAST

It has already been stated that one section exists within the eastern half of the United States where the temperature in winter normally averages lower than the lowest winter mean recorded in Japan. This is the northern interior, in which conditions have been indicated as probably inimical to the Japanese beetle. At the opposite extreme, a section also exists, embracing much of the South Atlantic and Gulf States, in which the temperature during the summer averages higher than the highest mean recorded in

hatch, while at 15° C. (59° F.) they take from 53 to 67 days. The average mid-summer temperature of Eastport is approximately 16° C. (60.8° F.). The low temperatures of the late spring (50°-52° F.) and early summer (52°-60° F.) at that locality would retard development of the insect, so that adult emergence could scarcely occur and egg deposition begin before August 1. In consequence hatching would not start at the earliest before September 1, and with the rapidly falling temperatures of that month (mean 55.8° F.) it seems unlikely that the resulting larvæ would consume sufficient food before cold dormancy sets in to enable them to survive. Ludwig (1928, B) has shown that while recently hatched larvæ which have fed for some time prior to hibernation are capable of surviving the winter, those which have not fed soon perish if exposed to a temperature no lower than 10° C. (50° F.).

Japan. In this country the isotherm of 25° C., the highest summer mean of Japan, coincides very nearly with the northern limits of the Cotton Belt, as mapped in the publications of the Department of Agriculture (*e.g.*, Agelasto *et al.*, 1921). It is noteworthy that up to the present no instances are certainly known of the permanent establishment of the Japanese beetle south of this isotherm.⁹ However, no facts are definitely known which would preclude the eventual extension of the insect's range across the intervening country to Florida and the Gulf Coast. In Japan, as previously noted, the ocean, rather than any extremes of temperature, forms the obvious barrier to any further spread of its range south of its present limits in that country. In the United States, in the absence of a definite geographic barrier, no apparent obstacles exist to prevent the southward spread of the beetle. Evidently the southward limitation of its range in Japan to a district with a summer mean of 25° C. (77° F.) can scarcely be accepted as a valid criterion of any incapacity on its part to occupy all that portion of the eastern half of this country which has a summer mean in excess of 25° C.

Although it cannot be definitely asserted that any clearly demonstrated barrier exists to the future spread of the Japanese beetle throughout the South Atlantic and Gulf States,¹⁰ certain features of the life-cycle of the beetle suggest that the high temperatures, and consequently prolonged season of insect activity, in that section may prove less favorable to it than might be expected. High temperatures, if not extreme, accelerate development. Although, on the basis of results reported by Ludwig (1928, A), it cannot be premised that the rate of development of the Japanese beetle is controlled by temperature alone, nevertheless the bare possibility exists that, under temperature conditions like those of

⁹ Scattered occurrences of the beetle have been reported south of this isotherm as far as Charleston, S. C., and, according to more recent information furnished by J. L. King, to Atlanta and Savannah, Ga. However, the small numbers taken in most of the localities, as well as the fact that all except a few of the occurrences are situated close to the isotherm in question, leaves problematical the permanent establishment of the species at any point located well within the Cotton Belt.

¹⁰ Excepting those parts of Texas which have an average summer rainfall of less than 10 inches.

the Southern States, the insect, by the time winter sets in, will have reached a stage in its life-cycle at which it appears to be highly sensitive to even moderate cold. This is the stage known as the prepupa when the larva is in process of transforming into the pupa. Such prepupæ reared experimentally have been found to perish in large numbers when chilled for a day or two at a temperature no more extreme than 40° F. If temperatures in the South remain sufficiently high during the season of active growth to bring a large proportion of the larvæ to this critical stage before the arrival of winter, it is at least possible that the subsequent chilling to which they would be subjected would result in a high mortality. Such mortality, if it occurred, would tend to keep the Japanese beetle populations of the region greatly reduced compared with those represented in more northern latitudes and, as a result, to retard their further spread.

The question of the possible establishment of the beetle in tropical and subtropical Florida merits special consideration. Even though it may be unable to cross the Cotton Belt, there remains the probability of its introduction into that section of the state through artificial conveyance. Since experiment has clearly shown that the Japanese beetle is capable of passing through its complete life-cycle at temperatures between 17.5° and 27.5° C. (63.5° and 81.5° F.), the temperature of southern Florida would offer no obstacle to its establishment. At all times of the year, as at Tampa, for example, the average temperature falls well within the limits of safety for the species, in winter rarely falling below 50° F. and in summer seldom averaging above 81.5° F., while the rainfall is copious, especially during the warmer half of the year. Under such conditions the beetle would be able not only to survive but would probably be two-brooded, since two generations a year have been obtained experimentally when reared at 25° C.

There remains, of course, the chance that factors other than climate might interpose a barrier to the permanent establishment of the species. Much of the soil of southern Florida is sandy and rather porous and it has been found that in those sections of New Jersey where such soils predominate the beetle has remained decidedly scarce as compared with its numbers in the sections having

the finer and more loamy soils. Moreover, the native vegetation of southern Florida is largely composed of dry and coarse types of plants and the land as a whole appears unsuited for the support of such tender and succulent grasses as form the bulk of the plant cover in the usual haunts of the insect in the North. However, the recent transformation of extensive sections of southern Florida into country estates and farm lands has radically changed the original conditions and doubtless made the country more favorable for colonization by the beetle.

The foregoing remarks would doubtless apply to all sections of tropical or subtropical America where the rainfall is copious and the soil and vegetation suited to the beetle.

SUMMARY

The known reactions of all stages of the Japanese beetle to different degrees of temperature and humidity indicate its adaptation to countries with (1) a range of temperature capable of keeping the mean summer temperature of the soil occupied by the insect within the limits (17.5° C. and 27.5° C.) favorable for the hatching of the eggs and the survival of the larvæ, and (2) a precipitation copious in amount and rather uniformly distributed throughout the year.

The temperature of the soil in the type of ground inhabited by the Japanese beetle throughout most of its life-cycle is indicated as averaging slightly higher than that of the air during the season of growth and development. This fact needs to be considered when the seasonal mean temperature of a locality is taken as an index of its suitability for the permanent establishment of the beetle.

Precipitation is indicated as influencing survival through its effects on the moisture content of the soil, especially during the season of egg deposition and hatching. Greatly reduced beetle populations in the area in this country where the beetle is normally abundant have been correlated with summers of deficient rainfall.

Precipitation in winter influences survival by providing the covering of snow, which in regions with air temperatures fatal to the species serves to keep the temperature of the subjacent soil well within the limits of cold tolerance of the larvæ. 15° F. is indicated as the lethal point under natural conditions.

In Japan the low temperature of the summers near the northern limits of its range is probably the limiting factor in determining the spread of the beetle in that direction rather than the cold of the winters. At its southern extremity further spread is barred by the ocean. For this reason the climatic conditions coincident with the southern limits of the beetle's range in its native land cannot be utilized as a valid criterion of any incapacity on its part to establish itself in countries with a warmer climate than Japan.

In this country it seems highly probable that the Japanese beetle will eventually spread throughout and become permanently established wherever the normal conditions of temperature and precipitation most nearly resemble those of Japan. The region so characterized lies east of the 100th Meridian and, in general, extends from the lower Canadian provinces south to the upper limits of the Cotton Belt, formed by the summer isotherm of 77° F. (25° C.). Within these limits the beetle is likely to find conditions most congenial in the section bordering the Atlantic, but it will also find them nearly as favorable in the interior, as in the Mississippi valley, where, however, the greater frequency of prolonged droughts in the summers will probably tend to keep it less abundant than east of the Appalachians.

Rainfall, especially in summer, is indicated as the major limiting factor in determining the future range of the Japanese beetle in North America. It is apparently not adapted to an arid or semi-arid climate and hence is not likely to become generally established in the western half of this continent.

In that section of this country which extends from the Great Lakes east to the Atlantic, where the precipitation is normally copious throughout the year, the effective barrier to the northward spread of the beetle will doubtless be the low temperature of the summer rather than the severity of the winters.

In the region lying west of and in the same general latitude as the Great Lakes and extending thence west to the Missouri River, where the precipitation in winter is normally light, the extreme cold of the winters in combination with a wide-spread absence of snow is likely to be the limiting factor in stopping the northward advance of the beetle.

In those limited portions of the West where precipitation, or the accumulated moisture in the ground, would favor the establishment of the beetle, as on the crest of the higher mountain ranges and the more northern sections of the Pacific coast, the low temperature of the summers would doubtless prove effective in preventing it.

In the eastern half of this country no geographic barrier exists to hinder the eventual southward spread of the beetle across the Cotton Belt to Florida and the Gulf Coast, although the possibility is indicated that its spread south of the summer isotherm of 25° C. (77° F.) may prove difficult owing to the shortening of the life-cycle resulting from the high temperature and long duration of the growing season. This suggests the possible appearance late in the season of stages likely to succumb to even the moderate cold of a southern winter.

The climate of southern Florida, and of practically all sections of tropical or sub-tropical America in which rainfall is copious, is indicated as highly favorable to the Japanese beetle on the basis of experimental results. The possibility exists, however, that factors of a non-climatic nature, such as the character of the soil or the composition of the vegetation, may serve as barriers to its establishment despite the favorable climate.

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NEODIPRION SERTIFER

Forest plantations and even ornamental trees, of red pine and Scotch pine in the vicinity of Gladstone, New Jersey, are suffering serious damage, complete defoliation in some cases, through feeding of the sawfly, *Neodiprion sertifer* (Geoffrey). Eggs of this insect were found (May 1, 1939) by the writer on the needles of *Pinus ponderosa* (Western Yellow Pine). Feeding on the needles of this species has since been observed. The record is of some interest in that this species of pine has a very heavy needle, and only rarely are eggs of the insect laid in the needles of Austrian pine, which though stiff, are not as heavy as those of Western Yellow Pine.—FRANK A. SORACI.

A STUDY OF THE SUBSPECIES OF ODONTOMACHUS
HÆMATODA (L.) OF THE UNITED STATES
(HYMENOPTERA: FORMICIDÆ)

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Few ponerine ants are as easily recognized as are the species of the genus *Odontomachus*. The linear mandibles attached very near each other at the middle of the oral margin of the head, the oblique antennal fossa on each side of the head between the eye and the frontal carina, and another impression posterior to the eye, and the petiole usually terminating dorsally in a spine or acute point above readily distinguish these ants from all other closely related forms.

The hundred or more species, subspecies, and varieties are widely distributed over the warmer regions of the earth. One of the species, *Odontomachus haematoda* (L.), is noted for its innumerable variants, which include among them the subspecies treated in this paper. *O. haematoda* (L.), according to Emery, occurs in Central and South America, Africa, Madagascar, Ceylon, India, Oceania, New Guinea, and the Malaysian Islands.

These ants form small or moderate-sized colonies in the ground or in rotten wood. They are especially noted for their flesh-eating habits. Wheeler, however, found that workers of *Odontomachus haematoda clarus* Roger, when confined in an artificial nest, were omnivorous, feeding on sugar, cake, bread, and egg yolk.

The workers have the peculiar habit of leaping backward several inches when their mandibles are closed suddenly and forcibly. The closing of the mandibles in such manner causes an audible clicking noise.

The various castes of *Odontomachus* are characterized by Emery in *Genera Insectorum*, Fascicule 118, pp. 88-89 (1911), as follows:

WORKER: Antennal fossæ confluent in a depression behind the frontal carinæ; an oblique ridge from the eye separating the antennal fossa from an equally oblique and marked impression on

the side of the head. The apical and subapical teeth of the mandibles sharp, medial border of each mandible covered with small teeth, which scarcely enlarge from the base to the apex, and remain much smaller than the terminal teeth. Maxillary palpi 4-segmented, labial palpi 3-segmented. Eyes well developed. Petiole surmounted by a conical node, terminated by a sharp spine.

FEMALE: Winged. Eyes larger than with the worker. Possessing ocelli. Otherwise similar to the worker.

MALE: Mandibles very small. Maxillary palpi 6-segmented. Antennæ very long; scape very short, thicker than long. Petiole surmounted by a node usually pointed at the apex, but not terminated by a spine. A very distinct constriction following the postpetiole. Pygidium terminated by a spine.

The material forming the basis of this study has been obtained from the following sources: Museum of Comparative Zoology of Harvard University, United States National Museum, and the private collections of Drs. W. M. Mann, W. S. Creighton, A. C. Cole, and L. G. Wesson. The writer wishes to express his appreciation to these friends and the museums for the loan of the specimens.

A study of numerous specimens of the subspecies of *Odontomachus haematoda* (L.) shows high variability in many characters such as pilosity, color, and the length and shape of the petiolar spine. This leaves but few stable characters on which to base the redescriptions and keys here given. Of the four subspecies treated in this article, the two that are most easily confused are *clarus* and *coninodis*. Wheeler no doubt recognized this when he stated that he considered *coninodis* a depauperate mountain species derived from *clarus*. Should one have a single specimen of either of these to identify, he may have some difficulty in determining to which of the two forms the specimen belongs; with numerous specimens from a single colony, however, identification is not so difficult. For the latter reason the writer has hesitated to synonymize one of the forms.

KEY TO THE SUBSPECIES OF *ODONTOMACHUS HAEMATODA* (L.) OF THE UNITED STATES (FOR THE IDENTIFICATION OF THE WORKERS)

1. The posterior third or more of the prothoracic disk with distinct longitudinal striæ; color ranging from brown to deep brownish black; 7.5-9 mm. long; Florida and Georgia *O. h.* subsp. *insularis* Guérin

- The posterior third of the prothoracic disk with distinct transverse striæ; color lighter, ranging from pale yellowish brown to very dark reddish brown; principally the Southwestern States 2
2. Petiolar node conical, without a well pronounced spine; color pale yellowish brown; 6-8 mm. long *O. h. subsp. coninodis* Wheeler
- Petiolar node with a distinct, acuminate spine; color darker, ranging from reddish brown to dark reddish brown 3
3. Large, robust, 9-10 mm. long; color very dark reddish brown; head of the larger workers with distinct posterior ocellar pits, and usually an erect hair near each *O. h. subsp. desertorum* Wheeler
- Smaller, less robust, 7-8 mm. long; color a lighter reddish brown; posterior ocellar pits indistinct or absent *O. h. subsp. clarus* Roger

***Odontomachus haematoda* (L.) subsp. *insularis* Guérin**

Odontomachus insularis Guérin, Icon. Regne Anim. Ins., pt. 7, p. 423 (1845), worker.

WORKER: Length 7.5-9 mm. Larger than *clarus* or *coninodis*. Striæ on the prothoracic disk, although concentric, with a distinct longitudinal trend posteriorly. Dorsal border of petiole bearing a well defined, slightly curved, acuminate spine, whose tip is usually directed posteriorly. Erect hairs on the under surface of the mandibles, head, and base of femora; on the dorsal surface of the head and prothorax; and on the gaster and coxæ. Piligerous punctures of head discernible with artificial light even at low magnification with the binocular microscope. Color ranging from brown to deep brownish black.

TYPE LOCALITY: Cuba, no specific locality designated by Guérin.

Other distribution records as follows:

FLORIDA: Royal Palm Park (W. S. Blatchley); Lake Worth (P. J. Schmitt); Enterprise (W. M. Beutenmueller); Biscayne Bay (A. T. Slosson); Coconut Grove, Lower Matacombe Key, Paradise Key (W. M. Wheeler); Tallahassee, Gainesville, Miami, Monticello, Lakeland, Deep Lake (A. E. Wight); St. Petersburg (H. Raster); Wildwood (J. B. Hull); Rock Springs (S. O. Hill); Polk County (G. R. Vanderford); Haw Creek, Fort George, Crescent City, Hanover, Sand Point (Collector unknown).

GEORGIA: Bainbridge, Duckert, Spring Creek, Billy's Island, Okefenokee Swamp (J. C. Bradley); Thomasville (H. S. Peters); Savannah (collector?); Valdosta (H. T. Vanderford).

The above redescription is based on numerous workers from various localities in Florida and Georgia.

The most outstanding characters of this subspecies are the nature of the sculpturing of the prothorax, the size, the color, and the distribution in the United States.

This subspecies is widely distributed throughout Florida, probably occurring in every section of the State. It is known also from the extreme southern part of Georgia. There is reason to believe that *insularis* may eventually be found in that section of Alabama contiguous to Florida, especially extreme southeastern Alabama. Outside of the United States *insularis* has been reported from a number of the West Indian Islands.

***Odontomachus haematoda* (L.) subsp. *coninodis* Wheeler**

Odontomachus haematoda coninodis Wheeler, Bull. Amer. Mus. Nat. Hist., vol. 34, p. 391 (1915), worker, female.

WORKER: Length 6–8 mm. Closely related to *clarus*, and of somewhat similar appearance but differing in the following characters: Smaller average size, paler, more yellowish-brown color, and shape of the petiole, which is conical above and without a distinct, acuminate spine. Posterior third of the prothoracic disk with distinct transverse striæ.

TYPE LOCALITIES: Miller and Hunter's Canyons (W. M. Wheeler), Ramsey Canyon (W. M. Mann) Huachuca Mountains, Arizona. Altitude 5,000–7,000 feet.

This redescription is based on five cotype workers collected by W. M. Wheeler in Hunter's Canyon, and seven workers collected by W. S. Creighton in Ramsey Canyon.

The most outstanding characters of *coninodis* are the shape of the petiolar node, general color, and direction of the striæ on the posterior third of the prothoracic disk.

There is scarcely any doubt that *coninodis* was derived from *clarus*.

Wheeler states that this subspecies "forms small colonies and nests under stones."

***Odontomachus haematoda* (L.) subsp. *desertorum* Wheeler**

Odontomachus haematoda desertorum Wheeler, Bull. Amer. Mus. Nat. Hist., vol. 34, p. 391 (1915), worker.

WORKER: Length 9–10 mm. Strikingly large and robust.

Color a highly characteristic deep reddish brown. Petiole with a distinct, curved, acuminate spine, the tip of which is slightly directed posteriorly. Posterior third of the prothoracic disk with definite transverse striæ. Head with a well defined pair of posterior ocellar pits, each of which usually has an erect hair near it.

TYPE LOCALITY: "Dry arroyo back of Carnegie Desert Laboratory, near Tucson, Arizona" (W. M. Wheeler).

Other distribution records as follows:

ARIZONA: Phoenix (L. C. Murphree) (A. C. Cole); University of Arizona campus, Tucson (Robt. Wesson); and Tempe (L. C. Murphree) (A. M. Calaway).

Redescribed from two cotype workers collected by Wheeler near Tucson, and from numerous other workers taken at Tucson, Phoenix, and Tempe by the above-mentioned collectors.

This subspecies is especially characterized by its large and robust size, rich reddish brown color, acuminate petiole, transverse striæ on the posterior third of the prothoracic disk, and distinct posterior ocellar pits on the head.

Robert Wesson stated in a letter to the writer that he believes this subspecies to be rather common at Tucson but not often seen. He also inferred that the ants may forage more at night and the very early morning than during the warmer and brighter parts of the day.

***Odontomachus haematoda* (L.) subsp. *clarus* Roger**

Odontomachus clarus Roger, Berl. Ent. Zeitschr., vol. 5, p. 26 (1861), worker.

WORKER: Length 7-8 mm. Very similar to *coninodis* but differing in its average larger size, darker color (reddish brown), and the well developed, acuminate spine on the superior border of the petiole. Posterior part of the prothorax with distinct transverse striæ.

TYPE LOCALITY: Texas, no specific locality mentioned by Roger.

Other distribution records as follows:

TEXAS: Austin, San Antonio, Marble Falls, Fort Davis, San Angelo, Milano, Alpine (W. M. Wheeler); Marathon and Fort Davis (W. S. Creighton); Meridian (W. H. Long).

LOUISIANA: Provencal (M. R. Smith).

The above redescription based on numerous workers from Milano, Ft. Davis, Marathon, and Austin, Tex., and San Miguel, Mexico.

Odontomachus haematoda clarus is distinguished from the other subspecies here mentioned by its size, color, petiolar spine, and transverse striæ on the posterior third of the prothoracic disk.

This subspecies and *coninodis* are strikingly similar in general appearance. The writer has seen workers (presumably from the same colony) of *clarus* with considerable variation in the length and form of the petiolar spine. Had the specimens with very blunt spines been stray or single specimens it would have been almost impossible to distinguish them from *coninodis* on the strength of this character alone.

This subspecies ranges from Mexico through Texas into western Louisiana. Wheeler has recorded the species from the Huachuca Mountains of Arizona. As the writer has some doubt about the validity of the determination on which this record is based, he has not listed the locality above.

PROTHORACIC GLANDS OF ADULT LEPIDOPTERA

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INTRODUCTION

The presence of gland-like pouches on the prothorax of certain Lepidoptera has long been known, but the general nature of these structures has never been clearly determined. It is the purpose of this paper to inquire into the nature of the glands and their secretion, and to ascertain some facts concerning their function. The writer wishes to express appreciation to Prof. A. B. Dawson for his help and suggestions concerning the histology.

EARLIER WORK

Degeer (1752, 1778) was the first to record the presence of prothoracic glands in adult Lepidoptera. He observed the secretion of two drops of clear transparent liquid from the dorsal anterior region of the thorax (*Arctia caia* L.) and figured the approximate location of these drops. These were secreted when the moth was disturbed. Degeer believed this to be an original observation. Zeller (1840) stated that beneath the neck collar (*Arctia caia*) were two red tufts of hair which upon irritation of the moth became visible. These hairs clothed the glands which opened sideways. A drop of yellow liquid could be squirted out to a distance or could be reabsorbed. Squirting occurred not more than twice. Zeller thought the supply was then exhausted. The liquid possessed an odor similar to that of coccinellids or fresh fluid from poppy stalks and tasted as sharp as the former. Fenn (1890) reported the secretion of pale greenish or yellowish fluid from the dorsal anterior portion of the thorax of *Liparis salicis* L. (*Stilpnotia salicis* L.) when the animal was annoyed. Griffiths (1890) in reporting the same for *Arctia caia* added that the glands were whitish processes larger at the orifice than below, and the fluid gave an acid reaction with litmus. He postulated that the fluid was for defense since the moths were distasteful to birds. Webb (1890) reported that the glands occurred in many Cuspi-

dates (this probably refers to *Apatela*) and probably secreted a form of formic acid. Reid (1891) reported their presence in cocoon forming Bombyces, *Dicranura*, and also *Viminia myricæ* Gen. (*Apatela myricæ* Gen.). He postulated that the secretion aided in emergence from the cocoon (*B. quercus* L. (*Lasiocampa quercus* L.) or *D. vinula* L.) since the cocoon just before emergence was moist in this area, and the glands were flowing freely. The secretion was most plentiful at emergence and diminished with age. Portschinsky (1892) reported the odor (*Arctia caia*) as resembling that of coccinellids. He figured the attitude of the moth in the act of secreting and inferred that this was a protective device. He is quoted by Schulze (1912) as saying that no secretion occurred in *Arctia villica* L., since the white thoracic spots imitated the protective secretion. Uffeln (1909) described the secretion from the prothorax of a female (*Arctia caia*) as being an oily yellow, watery clear fluid smelling like nettle. He postulated that it was either repellent or attractant in nature. Dampf (1909) figured the location of the glands with reference to the patagia. The patagia were elevated by the entrance of blood into the membranous parts of the thorax. He reported the glands in Zygaenids and *Callimorpha dominula* L. Hollande (1911) defined the location of vesicles with reference to the patagia (*Stilpnotia salicis* L.). These vesicles already filled with blood were filled with more. With sufficient pressure there arose on the internal angle of each a drop of liquid. *Hyponomeuta* (syn. *evonymellus* Scop.) *cognatellus* Hubner emitted blood from the side edges of the neck due to the rupture of a small vesicle. *Argyresthia nitdella* Fab. secreted under the patagia also by means of a small rupture. In *Spilosoma menthastri* Esp., *Lithosia griseola* Hubner, *Hypocrita jacobæ* L., and *Arctia flavia* Fuessl., secretion occurred as in *S. salicis* L. *A. flavia* Fuessl., threw two orange jets more than twenty centimeters. *Zygaena trifolii* Esp., gave forth blood at the articulations of the coxæ with the thorax due to ruptures. Hollande stated that in the above named species the fluid emitted was definitely blood in contrast to the case of *Spilosoma fuliginosa* L. (*Phragmatobia fuliginosa* L.) where there were true glands under the patagia which took the place of the blood vesicles. These glands were bifurcate and pyriform. Hollande pricked a male

moth and found that the glands could no longer be elevated. When the blood coagulated in the wound or the wound was closed with celloidin, the glands elevated normally. In this way he proved that the pressure of the blood in all cases which he examined was responsible for the elevation of the glands and the blood vesicles. He further proved by decapitating *Stilpnotia salicis* L., with a ligature to prevent the loss of blood that the action of the glands and vesicles was reflex. Schulze (1912) figured the glands of *Spilosoma luteum* Hufn., showing their relation to the patagia. He also showed a photomicrograph upon which the aperture of the gland is indicated as being at the inner edge of the patagium. After reviewing the literature (1913) he said that the fluid in a freshly emerged female (*Arctia caia*) was clear as glass on the right side and turbid yellow on the left. After the glands were wiped and squeezed, both secreted yellow. Ten different people were not able to perceive the odor. He thought possibly that the secretion was thrust out first, followed by clear blood; but he did not believe that the blood of *Arctia caia* smelled like coccinellid blood. Schultz (1914) found no glands in the patagia or on the prothorax of *Stilpnotia salicis*, *Arctia caia*, and *Hyponomeuta evonymella*. Isaak (1916) stated that the glands (*Arctia caia*) were located on the mesothorax and were either light producing or glowing organs since the secretion shone green in the dark. The light beamed for ten seconds and was then withdrawn. It occurred in both males and females. Soldanski (1916) summarized Isaak's and Schulze's papers and said that he was unable to see shining. He reported that many other observers had met with the same failure. Aue (1916) summarized Isaak's paper. Hykes (1917) listed and reviewed a portion of the literature on these glands. Aue (1918, 1918a) described the fluid as being crystal clear and lasting for five seconds before being reabsorbed. He gave the location as on the thorax behind the head. He was unable to observe any shining in the dark. Just (1918) listed the literature on the subject up to 1918. Aue (1922) listed a portion of the literature. He described the liquid as being clear and colorless. It had a very penetrating odor, burned the tongue, yet was not tasty, and was not luminous. He found the glands in males.

ANATOMY

The two glands in *Apantesis arge* Drury lie on the dorsal side of the prothorax and not on the mesothorax as Isaak (1916) stated. Each is essentially a soft membranous pouch lying under and hidden by the patagium. Viewed from the side (Fig. 3A) the gland is seen as a lobe which is continuous with the intersegmental membrane and is bounded anteriorly by the "Spange"

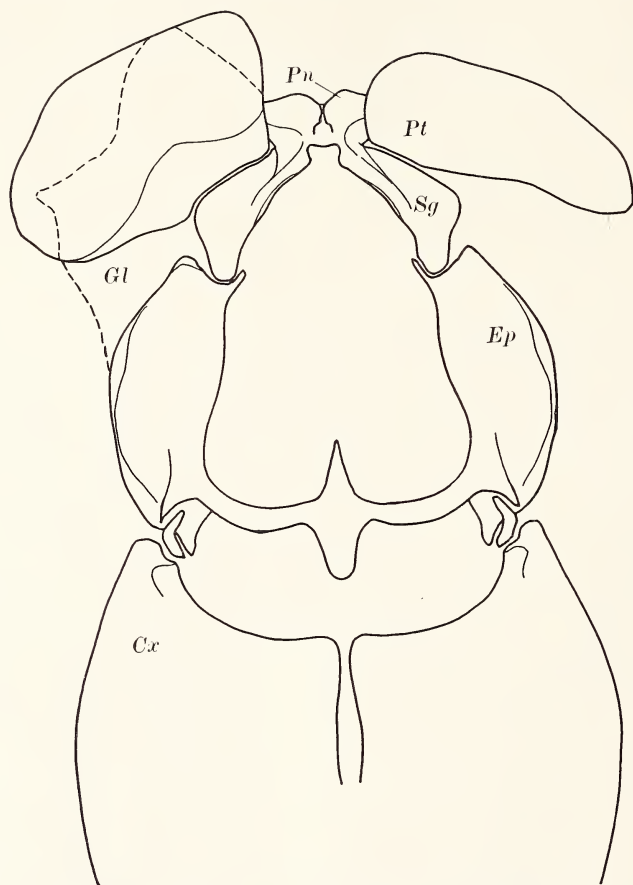


FIG. 1. Front view of the prothorax of *Apantesis arge* showing the relation of the gland to the skeletal parts. The right patagium is raised as in the act of secretion. Pn, pronotum; Pt, patagium; Sg, "Spange" of the episternum; Gl, gland; Ep, episternum; Cx, coxa.

of the episternum and by the patagium. It is bounded laterally by the episternum and on the median side by the pronotum (Fig. 3B). Posteriorly it is limited by the scutum of the mesothorax (Fig. 3A). The mesothoracic spiracle lies ventral and slightly posterior to the gland. When the moth is viewed from the front, the gland is completely hidden by the patagium (Fig. 1). The gland itself is but slightly smaller in area than the patagium (Fig. 3B) and is densely clothed with hairs and scales. Its dorsal surface is directly continuous with the ventral surface of the patagium. On the dorso-lateral surface of each gland is a prominent tit which does not, in this species, lie at the inner edge of the patagium as Schulze (1912) figured for *Arctia caia*. This tit, which marks the aperture, is conspicuous because it is usually heavily pigmented, heavily chitinized, and more thickly clothed with scales than the rest of the gland. Oftentimes a bit of secretion will dry on these very dense hairs and completely block the aperture.

HISTOLOGY

Live males and females of *Apantesis arge* were killed and fixed in ninety-five per cent alcohol. Other fixatives were not available in the field, and this was deemed sufficient for determining general histological details and topographical relationships. The insects were infiltrated with two, four, six, eight, ten, twelve and fourteen per cent celloidin for a period of twenty-four hours each at a temperature of forty-five degrees centigrade. They remained an additional week in fourteen per cent while it thickened. Sections were cut at fourteen and twenty microns. Some were stained with Harris' hematoxylin and eosin; others, with Heidenhain's iron hematoxylin and alum.

The gland is a large pouch formed by the invagination of the hypodermis (Fig. 2). It is not connected directly with the body cavity as Hollande (1911) figured for *Stilpnotia salicis*. Its top and sides are composed of two closely applied layers of cells, the outer being the regular hypodermal cells which secrete the cuticle and among which are the trichogen cells of the scales, the inner being the invaginated portion and forming the internal roof, walls, and bottom of the gland (Fig. 2). Often there is a great deal of blood between these layers. There is also an exceedingly large

quantity of blood beneath the floor of the gland. In no instance were blood cells found within the gland itself, nor was any direct connection with the body cavity observed. The gland epithelium was composed of a single layer of surprisingly thin cells (Fig. 3C). They were so thin, in fact, that the nuclei bulged out, giving the string of cells a bead-like appearance. The nuclei were relatively

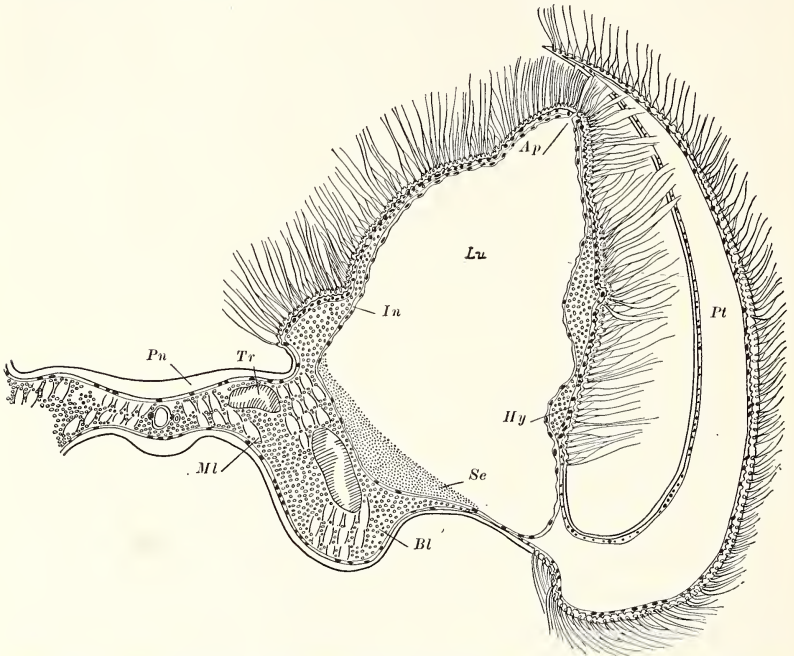


FIG. 2. Transverse section through the prothorax of *A. arge* showing the left gland only. The presence of the patagium in this section is due to its slight lateral overhang. Ap, aperture; Lu, lumen of the gland; In, invaginated cell layer; Hy, hypodermis; Se, secretion; Pt, patagium; Pn, pronotum; Tr, trachea; Ml, muscle; Bl, blood.

large but elongated. They were either solidly filled with chromatin or filled with large coarse granules. The small amount of cytoplasm present appeared to be relatively clear. Lying on top of these cells was an exceedingly thin clear cuticle. This seemed to be greatly folded so that it presented the appearance of many closely lying parallel ridges which were dentate when viewed in profile. In sections cut at right angles to the direction in which

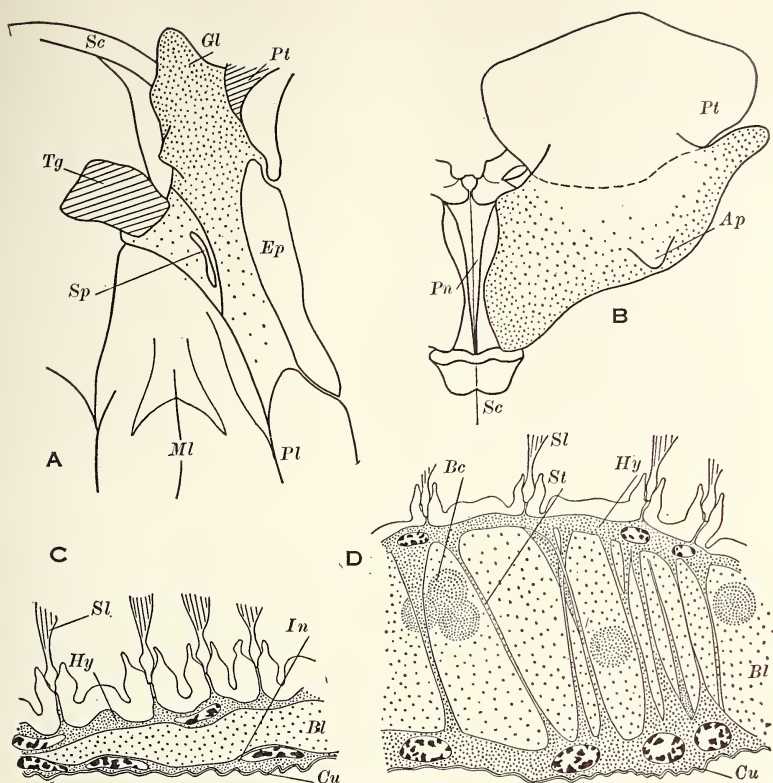


FIG. 3. A. The left side of the pro- and mesothorax of *A. arge* with the patagium and tegula removed. Sc, seutum of the mesothorax; Gl, gland; Pt, location of the patagium; Tg, location of the tegula; Sp, mesothoracic spiracle; Ep, episternum; Pl, prothoracic leg; Ml, mesothoracic leg. B. Dorsal view of the right side of the prothorax showing the patagium raised. Pt, patagium; Pn, pronotum; Ap, gland aperture; Sc, seutum of the mesothorax. C. Cross section of the gland wall of a moth several days old. Sl, scale; Hy, hypodermis; In, invaginated cell layer; Bl, blood; Cu, cuticle. D. Cross section of the gland wall of a freshly emerged moth. St, proto-plasmic strand; Be, blood cell.

the ridges ran, the ridges appeared as many fine short papillæ projecting into the lumen of the gland. Small masses of secreted material were seen close to the gland wall. These consisted of a homogeneous material ranging from finely granular to clear. Except for these the lumen was empty. The moths had been killed after they had secreted several drops.

Upon examination of a freshly emerged specimen which had not so far as was known secreted any liquid, it was found that the gland presented quite a different appearance (Fig. 3D). The distance between the two cell layers of the gland walls was very great. At no point did the two layers touch. The cells of the invaginated layer were slightly larger and more rounded than in the previous case. Their nuclei were also slightly larger and less flattened. Most remarkable, however, was the presence of numerous strands extending from the inner layer to the outer. These strands seemed to be cytoplasmic extensions of the inner cells but were morphologically continuous with the cells of the hypodermis. Blood filled the entire area. The patagia, which in other cases were empty, were here divided into sinuses by similar thin strands and membranes which stretched forth from the hypodermis on all sides.

FUNCTION

I first observed these glands while examining a female *Isia isabella* Abbot and Smith which had recently emerged from the cocoon. This specimen secreted four large drops of yellowish fluid from each gland. The last drops secreted were largely air bubbles which were reabsorbed before breaking.

Further detailed study was made upon *Apantesis arge* Drury. The secretion was a clear honey colored liquid which precipitated in ninety-five per cent alcohol as a cloudy white precipitate. It gave no test with litmus or phenolphthalein. It sank in water and was as miscible with water as is ninety-five per cent alcohol, leaving an oily spot on the surface. After a fifteen-minute exposure to air the fluid turned black. Under a high power microscope it was seen to contain many clear irregular particles of very small dimensions. In some instances the secretion possessed a slight musty odor; at other times it was odorless.

In order to determine the amount of liquid a moth was able to secrete, I caused three adults to secrete at definite intervals. The secretion was removed each time. All the data are summarized in Table 1.

Since no further secretion occurred after July 22, all three adults were killed on July 25. During this period of observation the moths were not fed. It was thus possible to compute the total

TABLE 1
AMOUNT OF LIQUID SECRETED AT CERTAIN TIME INTERVALS

Time	Moth A	Moth B	Moth C
July 20	Three drops from each gland		Two drops from each gland
July 21 6: 00 P.M.	No secretion (33 hrs. after emergence)	Two drops from each gland	Two drops
9: 00 P.M.	Four drops	Two drops	One drop
9: 20 P.M.	One drop (36 hrs. after emergence)	Two drops	Two drops
9: 30 P.M.	Two drops	No secretion	No secretion
9: 45 P.M.	One very small drop	No secretion	No secretion
July 22 9: 45 A.M.	One very small drop (mostly air)	No secretion	No secretion
6: 45 P.M.	One drop	One drop	One drop
July 23 Noon	No secretion	No secretion	No secretion
July 24 1: 30 P.M.	No secretion	No secretion	No secretion
Total from one gland	Twelve full sized drops	Seven drops	Eight drops

secretion of an animal which had taken in no liquid. Two of the drops that Moth A secreted were very minute and are counted as one thus giving a total of twelve drops from one gland or twenty-four from both. The minimum diameter of the drops was 1 mm. The volume of one drop was thus .00052 cc. Since there were twenty-four drops, the total secretion of the animal was .012 cc. Whether this figure would differ greatly from that of an animal which was allowed to feed is not known.

The maximum number of drops secreted at any one time from one gland was four; these were equal to a volume of .002 cc. The approximate volume of a gland as computed from a whole mount and sections was .002 cc. Thus it may be concluded that the capacity of the gland is very roughly equal to .002 cc. From Table 1 it may be seen that from three to twelve hours time is required to just partially replenish the supply.

No secretion could be obtained from a moth in the act of emerg-

ing; nor did it secrete till two hours afterwards. Other specimens which were tested a few hours after emergence secreted abundantly. One moth lived for eight days and was capable of secreting up to the time of death.

Secretion occurred only when the animal was disturbed by being touched at some point on the body. In one case, however, an individual secreted when the cover of the breeding cage was roughly lifted. Hollande (1911) observed that *Arctia flavia* threw the liquid a distance of twenty centimeters. This was also observed in *Isia isabella* but not in *Apantesis arge*. When the moth was left to itself, the patagia returned passively to their normal position (they were raised to allow secretion) (Figs. 1, 3B); and after ten minutes the secretion was reabsorbed by the glands. Even in one instance when the fluid had already turned black, it was drawn back.

Reid (1891) suggested that the secretion aided in emergence from the cocoon since just before emergence the cocoon was moist and the glands flowing freely. In *Apantesis arge* there is no cocoon to speak of, and the glands were not secreting at the time of emergence. Griffiths (1890) believed that the glands were protective devices. Uffeln (1909) said they were either repellent or attractant. I am inclined to favor Griffiths' interpretation especially in view of the fact that the glands may remain active during the whole lifetime of the individual and never function unless the moth is disturbed. Since both sexes possess these structures, I do not believe them to be attractant in function. Moreover, the secretion from *Isia isabella* and *Apantesis arge* is not luminous.

Up to the time of writing it has been definitely determined that these glands and vesicles occur in the following Lepidoptera: *Arctia caia* L. (Degeer, 1752, 1778), *Stilpnotia salicis* L. (Fenn, 1890), many cuspidates (Webb, 1890), cocoon forming Bombyces, *Dicranura vinula* L., *Viminia myricæ* Guén., and *Lasiocampa quercus* L. (Reid, 1891); zygænid and *Callimorpha dominula* L. (Dampf, 1909); *Hyponomeuta cognatellus* Hubn., *Argyresthia nitidella* Fab., *Spilosoma menthastri* Esp., *Spilosoma fuliginosa* L., *Lithosia griseola* Hubn., *Hypocrita jacobæ* L., and *Arctia flavia* Fuessl. (Hollande, 1911); and *Spilosoma luteum* Hufn. (Schulze,

1912). I have observed the glands in the following species: *Apantesis arge* Drury, *Apantesis virguncula* Kirby, *Isia isabella* Abbot and Smith, *Estigmene acraea* Drury, *Diacrisia virginica* Fab., and *Ecpantheria deflorata* Fab. The following dried specimens were heated in ten per cent potassium hydroxide and examined for the presence of glands. The type of structure found, if any, is described; but it is not definitely maintained that these are glands. The living animals or sections of preserved material must be examined for the final decision. The following list is arranged according to the Barnes and McDunnough Check List (1917).

Syntomidæ

Ctenucha virginica Charp. Pouches poorly developed.

Aretiidæ

Hypoprepia miniata Kirby Moderately developed pouches.

Hemilhayla edwardsi Packard Well developed pouches.

Halisidota maculata Harris Very poorly developed pouches.

Halisidota tessellaris A. & S. No well developed pouches.

Holomelina opella Grote Well developed pouches.

Holomelina diminutiva Graef. Well developed pouches.

Leptarctia dimidiata Streck. Rather well developed pouches.

Hyphoraia parthenas Harris Well developed pouches with a small chitinized tit on the inner margin of one.

Phragmatobia fuliginosa L. Well developed slightly bifurcate pouches.

Mænas vestalis Packard Small pouches.

Euerythra trimaculata Smith Very poorly developed pouches.

Hyphantria textor Harris Very small poorly developed pouches.

Arachnis picta Packard Well developed pouches each with a small chitinized tit.

Apantesis persephone Grote Well developed pouches.

Apantesis radians Walker Well developed pouches.

Apantesis phalerata Harris Well developed pouches.

Pygarcia abdominalis Grote Well developed pouches.

Euchætias egle Drury No well developed pouches.

Seirarctia echo A. & S. Well developed pouches.

Turuptiana permaculata Packard Very small poorly developed pouches.

Parasemia plantaginis L. Well developed with a chitinized tit on each.

<i>Platyprepia virginalis</i> Bdv.	Well developed pouches with chitinized ridges and no aperture evident.
<i>Utetheisa bella</i> L.	Well developed pouches.
<i>Haploa colona</i> Hubner	Well developed pouches.
<i>Haploa lecontei</i> Bdv.	Well developed pouches.
<i>Haploa militaris</i> Harris	Well developed pouches.
Agaristidæ	
<i>Alypia octomaculata</i> Fab.	No pouches.
Noctuidæ	
<i>Autographa brassica</i> Riley	No pouches present.
Notodontidæ	
<i>Datana ministra</i> Drury	Pouches poorly developed.
Lymantriidæ	
<i>Porthetria dispar</i> L.	Well developed pouches.
Lasiocampidæ	
<i>Malacosoma americanum</i> Fab.	No pouches present.

Without examining living material and fresh secretions one can not say definitely in how many forms prothoracic glands occur. Whether Hollande's blood vesicles are distinct from glands remains to be seen. As far as can be seen from Figure 3A the true gland extends as far down as the coxa. Whether the emission of blood from *Zygæna trifolii* Esp. at the articulation of the coxæ with the thorax is from a vesicle comparable to that in other forms also awaits determination. The occurrence of prothoracic pouches is very widespread in the Arctiidæ. Secretion of fluid from the region of the patagia has been reported from Lasiocampidæ, Lymantriidæ, Zygænidæ, Noctuidæ, Notodontidæ, and Yponomeutidæ.

CONCLUSIONS

1. The two prothoracic glands in *Apantesis arge* are located under the patagia. The aperture of each is heavily pigmented, heavily chitinized, and thickly clothed with scales. The glands occur in both males and females.

2. The gland is a pouch formed by invagination. The epithelial lining is composed of very thin cells with large nuclei. There is no direct connection with the body cavity. Blood cells do not enter the lumen.

3. The secretion is a clear honey colored liquid, oily, and miscible with water. It forms a white precipitate in alcohol, gives no reac-

tion with litmus, turns black upon prolonged exposure to air, appears to be slightly granular, and possesses at times a slightly musty odor. It is not luminous.

4. The total secretion of an animal which had taken neither food nor drink was .012 cc. The maximum amount capable of being secreted at one time from one gland was .002 cc. The capacity of the gland is roughly .002 cc. Three to twelve hours are required to partially replenish the supply. The moths under observation did not secrete at the time of emergence and were capable of secreting till death. Secretion occurred only when the animal was disturbed.

5. The glands of adult Lepidoptera are probably protective devices. They occur widely in the Arctiidae, and gland-like structures have been reported in Lasiocampidae, Lymantriidae, Zygaenidae, Noctuidae, Notodontidae, and Yponomeutidae. They are probably present in other forms also.

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SOME ADAPTIVE RESPONSES OF TAXONOMY TO A CHANGING ENVIRONMENT

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Although taxonomy in a very primitive sense long antedates the Linnæan system of binomial nomenclature, its present phase of development is inseparable from this system. Indeed, we may ask whether any other method could have been extended to meet so well the present needs of biological classification. Certainly no acceptable substitute has been proposed through the course of nearly two centuries during which innumerable taxonomists have described and classified, to the best of their ability, more than a million species of animals and plants.

The human race first learned to exploit the bounties of nature by a crude, though astute, knowledge of edible plants and food animals. This demanded an accurate discrimination of the characters of many species of plants and to a lesser extent of animals, and served incidentally to create the vague beginnings of pharmacology. The beginnings of taxonomy smouldered for centuries however, even after written language had become an established vehicle for recording complex ideas. It made little progress, in spite of a few sporadic attempts to classify, or at least to describe and place in an orderly arrangement a few of the more conspicuous living organisms.¹ Sometime before the appearance of the Linnæan "*Systema Naturæ*" the microscope had come into quite general use and the time was ripe for biologists to examine with considerable exactitude the structure of small animals like insects as well as the more minute anatomical details of many living things that had hitherto eluded observation by the naked eye.

If, as seems reasonable, we consider the birth of modern taxonomy as coincident with the publication of the "*Systema Naturæ*," we find a healthy new branch of science suddenly born after prolonged gestation. Like a newborn organism, its first

¹ These really include only the works of Aristotle, Pliny, Gesner, Aldrovandri, Ray and several botanists who shortly preceded Linnæus.

concern was growth. This involved development, differentiation, adaptation and a number of other phenomena always associated with growth which are familiar to all biologists.

Growth in individual organisms, and in populations, always follows a quite definite and prescribed course. Moreover, this is frequently true of many other types of utterly unrelated events such as the frequency of fundamentally new inventions and the popularity of certain social ideals, of dogmatic beliefs or even of rag-time music or jazz. As this phenomenon of growth is such a universal one, I have attempted to examine the progress of insect taxonomy on a similar basis. We may measure this by an examination of the productions of taxonomists over a period of time.

Since the field is a vast one a high degree of accuracy is impossible, but I have been able to collate with the aid of the "Zoological Record" a summary of the new names proposed annually by zoologists² over a period of somewhat more than half a century. This is represented in Figure 1 as a curve, the points on the curve being determined arithmetically by the addition of each annual increment. This curve has been smoothed on a three-year basis to reduce the irregularities introduced by the occasional appearance of some *magnum opus* or even the coincident publication of several such tomes during a single year. The similarity of this graph to a portion of the sigmoid growth curve of an individual animal is very striking. We should, of course, properly tabulate our material for the earlier periods also, but for practical reasons this has been impossible as there are no reliable sources for the necessary data. It would appear that the period we have selected includes the age at which the growth rate is undergoing acceleration, especially when we note the lag from 1914 to about 1920 which is undoubtedly due to the world war, and the rapid, overcompensated recovery after this time. Altogether during the period of sixty-five years from 1870 to 1934, 103,752 new names were proposed, equivalent to a mean annual increment of almost exactly 1600. The change in rate over the whole period is consistent, but not

² These names include, of course, new names proposed for others which have been invalidated as homonyms, but the number of these is small, and is distributed quite evenly from year to year. The annual totals also include the names later invalidated both as synonyms and homonyms, but this error is inevitable and would appear also to be of no great magnitude.

great and does not bear out the opinion that is frequently voiced by many zoologists that systematics has gone wild with the needless multiplication of generic names. Actually the number of new names proposed annually has approximately doubled after sixty-five years. This is certainly not out of proportion to the greatly increased number of workers, more abundant materials available and enhanced opportunities for study and publication. Moreover,

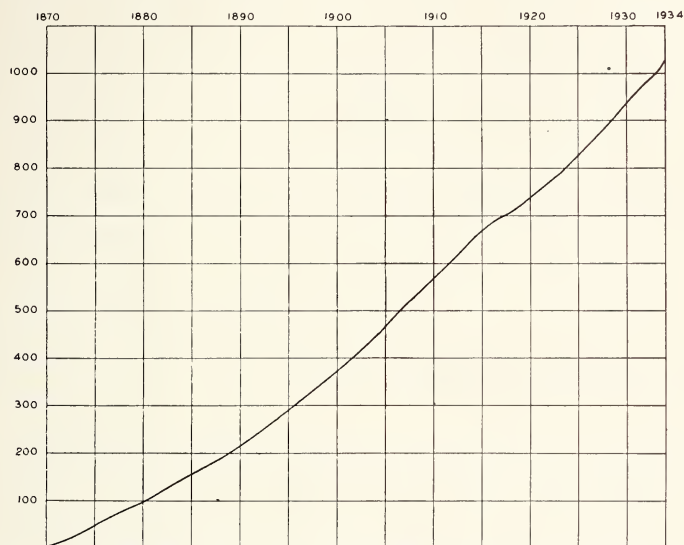


FIG. 1. Growth of generic and subgeneric names in use by taxonomists in the entire field of zoology, 1870-1934.

we have good reason to predict that taxonomy may still expect a long and productive life insofar as the recognition of new genera is concerned, and that the maximum growth rate has not yet been reached.

Since insects form the major part of living organisms, that have come under the taxonomist's eye, they should serve as a reasonable gauge of systematic biology as a whole. If we now turn to Entomology in particular and construct a similar graph based on the new names proposed for insects over a similar period we see a curve (Figure 2) which is more or less like the preceding one. It differs markedly, however in showing less clearly the sigmoid form,

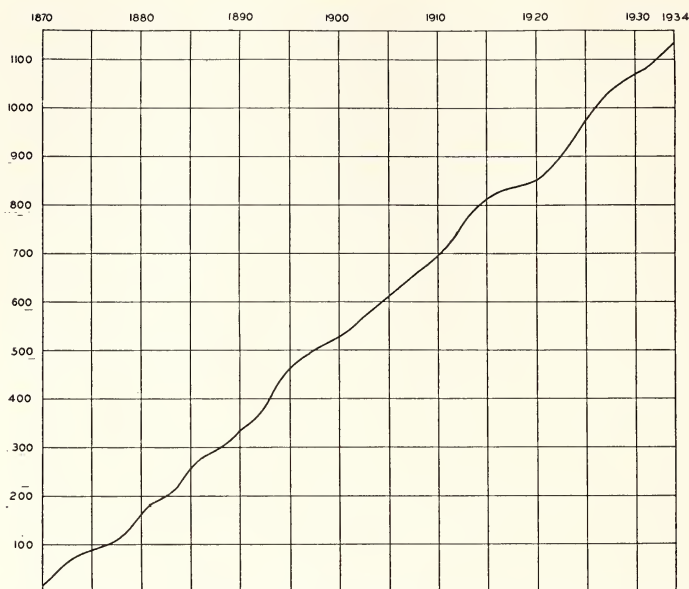


FIG. 2. Growth of generic and subgeneric names in use by taxonomists in the field of entomology, 1870-1934.

although this is slightly evident, and approaches more closely to a straight line, with a less noticeable disturbance at the time of the war (1914-1920). The reason for this difference from the whole zoological curve may indicate a later stage of growth, although it may be due to some other unsuspected factor, and were it not for the rather characteristic form of the first curve this one might not appear significant. If we turn to several orders of insects and consider these individually over a fifteen year period (Figure 3) we can see nothing but a generally consistent and uneven growth. Here undoubtedly the number of workers is so small that their variable output tends to produce considerable irregularities, and there is no indication that a longer and much more tedious compilation would be worth while. The several orders have not by any means attracted an equal number of workers, nor have they received approximately equal attention, nor is our knowledge of them equally complete, yet none of these variables are sufficiently correlated over a period of years to give any indication of changing or differential growth rates. The only consistent change is a

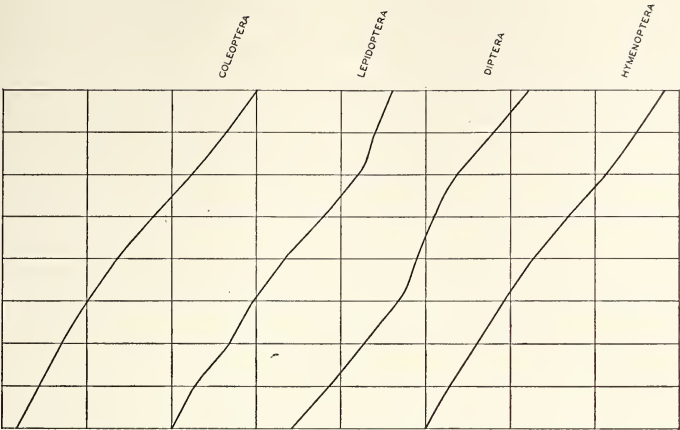


FIG. 3. Growth of generic and subgeneric names in use by taxonomists for several orders of insects (Coleoptera, Lepidoptera, Diptera and Hymenoptera), 1920-1934.

gradual, irregular increase in growth rate which holds true for each of the four orders.

As an indication of what might be expected of entomology in the future, I have compared the number of new names proposed

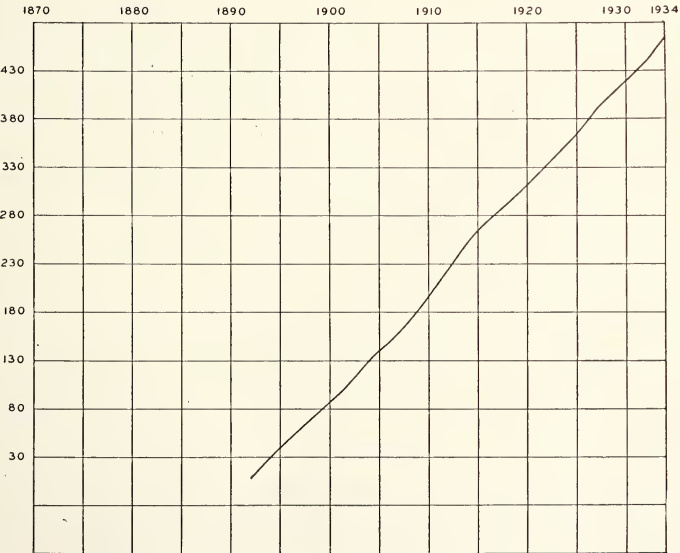


FIG. 4. Growth of generic and subgeneric names for birds and mammals, 1891-1934.

for birds and mammals over the period of 1921-1934. Since the discovery of new species in these groups is now very greatly reduced over former years we should expect to find an entirely different condition with reference to new generic and subgeneric names. In Figure 4 is plotted the additions for birds and mammals, resulting in a practically straight although wavering line, with no indication that taxonomic complexity depends for its growth on the continued discovery of hitherto unknown forms or organisms! The growth rate is apparently just about holding its own, with no significant increase or decrease. From this we may predict, with a considerable margin of safety, that after all the species of insects are known we shall continue, at least for a time and at a reduced rate, to reclassify, redistribute and redivide them into new genera and subgenera.

I have compiled one other series of data relating to a single restricted group of insects (Figure 5). For this purpose the

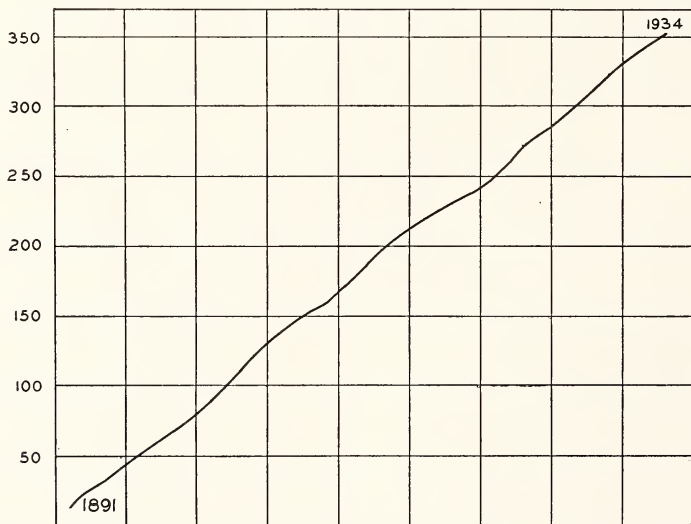


FIG. 5. Growth in number of described species of the family Cerambycidae (*sens. lat.*).

longicorn beetles (family Cerambycidae *sens. lat.*) were selected as these are attractive, usually large beetles that have been very extensively collected and should be much more completely known

than most other families of insects. The curve in this case shows the numerical growth of known species as described from year to year from 1870 to the present time. As might be expected this curve is very irregular, due to great annual fluctuations resulting from the comparatively small number of papers that contain descriptions of new species. The growth rate wavers nervously about a nearly straight line, indicating a practically constant rate of increase in the number of known species. Actually the mean annual increment is 168 species, or 10,915 in 65 years.

This great growth of taxonomy, both in the number of its adherents and also in the rapidly increasing size of the complexes with which it deals, has had the inevitable result that follows the extension of any field of knowledge. There has come a gradual and consistent specialization. The entomologists of the earlier period became the coleopterists, hymenopterists, dipterists and orthopterists of the late nineteenth century. These are now gradually giving place to the myrmecologists, coccidologists, cynipidologists, empididologists and tachinidologists, *alias* larvævoridologists. This has meant a steady narrowing of the field for the individual systematic worker, coincident with the opportunity for a more complete knowledge of his own special field. We are now in this transition period and these changes appear to have been very generally a great gain for taxonomy. We must not forget however that our greatly specialized taxonomists of to-day had a much broader background than we may hope to find in later generations if the young entomologists of the future settle into isolated and comfortable niches before they acquire any first hand knowledge of the matters which engross the attention of their neighbors. We are, of course, referring here only to taxonomy and not to the other phases of biology, but it is a striking fact that among entomologists who are not primarily taxonomists, nearly all find occasion to devote some time to the classification of some group, large or small.

We cannot foresee the future growth of taxonomy as measured by the increasing number of genera and species that may be made known, more than to predict on the basis of the past 75 years that there is no indication that a maximum growth rate has yet been reached, nor that after that time a decline may be promptly expected to follow.

Great familiarity with a restricted group of insects or other organisms leads primarily to a better understanding of their similarities and the characters which distinguish them one from another. As they are more critically examined, these contrasting characteristics lead to a clearer recognition of generic grouping and specific segregation, and the natural result is the multiplication of genera and species. This follows consistently among practically all systematists and I do not believe that the designation of "splitters" and "lumpers" is really a valid distinction for the near future. At any rate the gap between proponents of these two types of procedure is now notably lessened, if we discard as non-taxonomic the classification of aberrations and the like among butterflies.

The early taxonomists did their work without any knowledge of organic evolution or of racial descent and consequently without any thought of the possible genetic relationships of living animals to one another and to their many long extinct ancestors. It might be argued that a vague idea of evolution may have influenced Aristotle in his classification of animals wherein he included altogether about 525 species, some of which were imaginary creatures existent only in the minds of their describers. However, any such notions were completely lost to all the later predarwinian taxonomists. Nevertheless taxonomic methods suffered comparatively slight changes following the general acceptance of evolution as a biological principle. This appears at first blush an almost unbelievable situation particularly as it was mainly the work of the taxonomists that gave the original theory its strongest support. The whole science of biology was rocked to its foundations at this period, yet the insect taxonomists went serenely on classifying animals in the same old way with only scant and parenthetical disquisitions on phylogeny and on the newly clarified aspects of relationships. To the minds of non-systematic zoologists this has been a cardinal sin and has led them to regard taxonomy as a pastime closely related to that of the stamp collector. As a matter of fact the phylogenetic approach to relationship was confined to a consideration of the larger categories of animals, and naturally enough also to those groups of much lesser extent than the insects or to those whose classification was not sufficiently advanced to

introduce the innumerable difficulties that beset the entomological taxonomist. Herein lies, undoubtedly, the reason for the apparent lack of appreciation on the part of entomologists of the bearing of evolution on the more detailed parts of their schemes of classification. More recently this condition has changed and is in general proceeding from a consideration of the higher categories and gradually ramifying into the smaller ones (families, tribes, genera, etc.). The influence of paleontology on the taxonomy of living animals was first felt after the doctrine of organic evolution had been advanced and has rapidly become highly important, for example, in the classification of reptiles and mammals. In like manner the recent extensive growth of insect paleontology has greatly furthered our knowledge of the relationships of many types of living insects.

The more recent entry of genetics into biology has again greatly changed the environment of taxonomy. Here likewise this new outlook has so far exercised a very slight, almost negligible influence on taxonomic procedure. In a few isolated instances genetical experimentation has served to elucidate the relationship of color varieties and polymorphic forms within species, but it has been thus far so very imperfectly correlated with the more general problems of evolution and speciation that it cannot be applied directly to taxonomic work. It is hardly open to question that genetics will in the future bring its understanding of the gene and the unit character to a stage that will allow of their application to taxonomy. Unfortunately, so far genic differences and mutations observed in the experimental sphere are concerned almost entirely with those types of structural peculiarities and deficiencies which cannot be correlated with the specific associations of both constant and variable characters which must form, after all is said and done, the workings basis of taxonomy. We may of course qualify this statement as has often been done by insisting that species are artificial concepts, non-existent in nature, and further that there is no essential agreement among taxonomists as to the limits of particular species. There is good basis for such qualifications in some instances, but it has been greatly overemphasized, and the question has frequently been clouded by a confusion of species, subspecies, geographic races, varietal forms, etc.

The latter categories were of little concern to the earlier taxonomists who made use of them in rather loose fashion. However, the recording of more extensive and exact data on the geographical distribution of species and the consequent recognition of the fact that variations may be associated with distributional range over contiguous areas has led taxonomists to enquire more closely into the status of subspecies and races. Thus through cooperation with zoögeography, taxonomy has secondarily entered the field of phylogenetics by a direct path and has become actively interested in the origin of species and higher categories, rather than their mere existence. This appears thus to be a long delayed response of taxonomy to evolution. Long delayed, in that the taxonomists have now begun to accumulate data with this end in view, rather than to furnish material for interpretation by others.

As the oldest branch of biology, taxonomy appears to be the most set in its ways, but even the foregoing brief citation of some of its responses to changes in biological thought demonstrate that it has by no means reached a stagnant condition. It is nevertheless far less labile than most other branches of biology. This is to be expected considering the vast entourage of genera and species with which it is encumbered on its onward march, not to mention the ghosts of their ancestors clamoring for a place in the parade as they are resurrected from the dead by inquisitive paleontologists.

INSECT FOOD HABIT RATIOS OF NORTH CAROLINA, AND MOUNT DESERT ISLAND, MAINE

BY HARRY B. WEISS

The recent appearance of Dr. William Procter's "Biological Survey of the Mount Desert Region, Part VI, The Insect Fauna," and of Dr. C. S. Brimley's "The Insects of North Carolina," has revived my interest in insect food habit types, and because of the large numbers of species recorded from these two regions, I have taken the liberty of classifying them in accordance with their family food habits in order to arrive at the ratios between the food habit types, and for the purpose of comparing them with ratios found in other areas.

At the outset, I may as well admit the difficulty of classifying families of insects in accordance with the food habits of their members. The feeding habits of many species are still unrecorded. In some families the larvæ and adults have different types of food habits. Some so-called saprophagous insects may not be saprophagous at all, but may feed upon micro-organisms found upon decaying and fermenting organic matter. In view of such difficulties it was necessary, in using the family as a unit, to classify some families in accordance with the predominating feeding habits of their members.

The terms saprophagous, phytophagous, etc., are used in their broadest sense and with the understanding, for example, that the saprophagous group includes coprophagous, sarcophagous, mycetophagous, zoö necrophagous, etc., insects and with the awareness that phytophagous insects feeding upon special parts of living higher plants present special conditions in nutrition. Uvarov believes that a classification of insects on their food habits should be delayed until such habits are better known and I agree with this principle. Nevertheless, I see no objection to generalizations based upon such information as exists.

In arranging the families of insects of North Carolina, and Mount Desert Island, into food habit groups, I omitted the Ano-

plura, Mallophaga, and Siphonaptera because of their non-relation to vegetation. A few other species were omitted also because of the difficulty of placing them in an approximately correct group. However, these omissions are of little importance considering the large number of species involved. It is realized also that lists of the insects of certain regions may of necessity be incomplete in certain parts, due to the absence of diligent collecting in some families, and for other reasons. In spite of such imperfections, a consideration of most of the recorded species shows the following food habit type groupings.

	No. Species	Phyto- phagous Per cent	Sapro- phagous Per cent	Harpacto- phagous Per cent	Para- sitic Per cent	Pollen Feeders, Etc., Per cent
North Carolina	9,249	46	17	22	11	4
Mount Desert						
Is., Me.	5,177	52	17	14	15	2

This table shows the distribution ratios of food habit types present in two large areas, each area embracing different types of vegetation. These ratios are expressed as percentages of the total numbers of species listed in the left hand column, regardless of the numerical abundance of individual species. As various species maintain themselves in certain numerical ratios with respect to factors or combinations of factors tending to reduce their numbers, and as these relationships are usually normal, such numerical ratios have been considered as constant.

The food habit ratios for the insects of North Carolina and Mount Desert Island do not differ widely from those of other large areas. This is shown in the next table, where three additional areas are considered.

In the five areas listed above, each embracing different types of vegetation, the distribution ratios of the types of food habits do not differ widely and suggest a fluctuating relationship within comparatively narrow limits. Although future additions to the numbers of species or more complete information about the food habits of many species would change the ratios somewhat, this would not affect what appears to be a "fixed" relationship, or balance.

In previous papers on the ratios of insect food habits, it was

	No. Species	Phyto- phagous Per cent	Sapro- phagous Per cent	Harpacto- phagous Per cent	Para- sitic Per cent	Pollen Feeders, Etc. Per cent
Western Arctic						
Coast, N. A.	400	47	27	14	10	2
New Jersey.....	10,500	49	19	16	12	4
Connecticut	6,781	52	19	16	10	3
North Carolina	9,249	46	17	22	11	4
Mount Desert						
Is., Me.	5,177	52	17	14	15	2
Total	32,107	49	18	17	12	4

brought out that in relatively small areas, each with a uniform type of vegetation, the ratios between the types of food habits, based on the species present, vary in accordance with the type of vegetation if the numerical ratios between the species and the factors tending to reduce their numbers are considered as constant.

When large areas, each embodying different types of vegetation, are considered, the ratios between the various types of food habits, based on the species present, vary but little when the numerical ratios between the species and the factors tending to reduce their numbers are considered as constant. This idea was advanced in previous papers and the additional evidence of the food habit ratios of the insects of North Carolina and of Mount Desert Island seems to bear this out.

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A NEW TRICHOTAPHE FROM NEW YORK (LEPIDOPTERA: GELECHIIDÆ)

BY WM. T. M. FORBES

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Specimens of the following species have been appearing from so many sources recently that it seems advisable to put it on record, especially since the food plant can be given. Mr. Latham has also taken a second undescribed *Trichotaphe*, but, as so far only a single specimen has turned up, its description will be postponed.

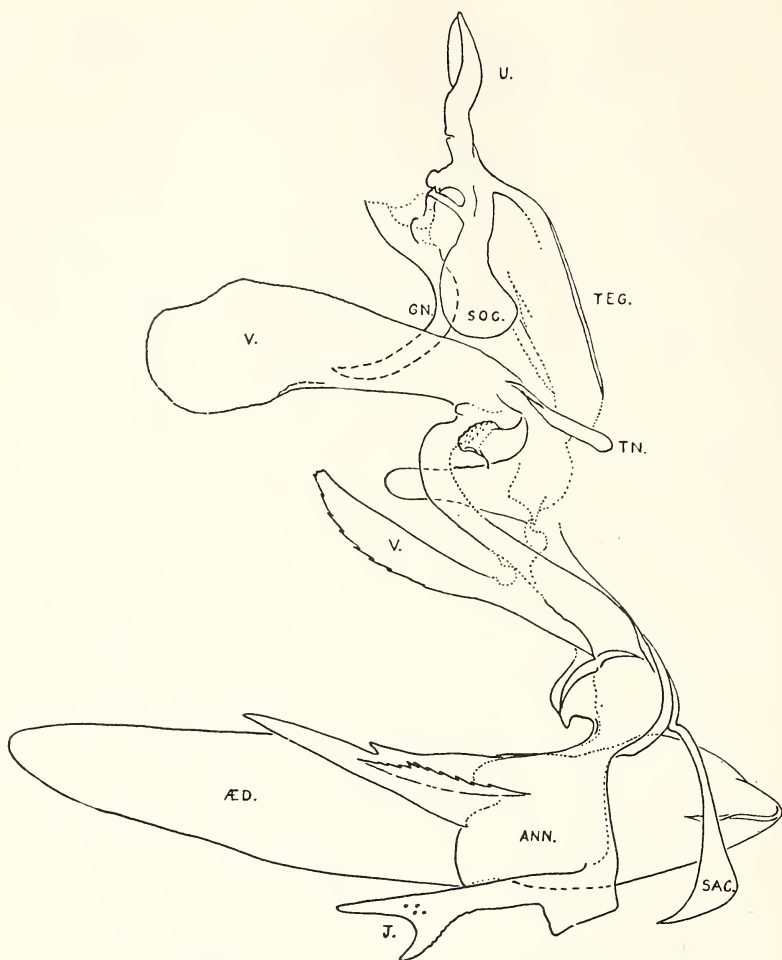
Trichotaphe iothalles new species

Antennæ with pubescence about as long as width of shaft; ocelli absent; palpi sickle-shaped, nearly smooth but with a little loose scaling on upper side of second and third joints, the second much thickened rather beyond the middle and then tapering again. Third hardly $\frac{1}{2}$. Male with an expansile lateral plume on prothorax. Fore wing with outer margin distinctly concave, the membrane subfalcate, but filled out nearly straight by the fringe; R_5 just above apex; hind wing with a distinct fringe on base of Cu, but otherwise normal for *Trichotaphe*. The species will key to *Trichotaphe* in Buseck (Proc. U. S. Nat. Mus., xxv, 772) and in my key (Lep. N. Y., Cornell Memoir, 68, 258), but will not in Meyrick's recent revision on account of the fringe on Cu. In the latter if construed strictly it will run to *Pachysaris* (South America) or *Carbatina* (India) according to how much weight is put on the loose scaling on the upper side of the palpus.

Glossy light wood brown, rather brighter than the clay color (17") of Ridgway. Head shading into fuscous; antennæ brassy and faintly ringed with fuscous; tongue and maxillary palpi almost blackish; labial palpi dark brown, shading into tawny at edges, the inner side of second segment bright ochre. Thorax concolorous "clay color," shading more or less into blackish on middorsal line, and with sides of collar and bases of tegulæ blackish. Abdomen gray, with pale base and tip. Legs luteous, heavily shaded with dark gray on outer sides; body luteous below, abdomen with first two and last segments contrastingly gray.

Fore wing with ordinary dots as black points, or nearly obsolete, the claviform directly below the orbicular; costa except toward apex and inner margin shaded with fuscous; terminal area contrastingly chocolate brown, broad at inner margin but narrowing to a point at apex; extreme margin marked by a fine contrasting straw yellow line, usually edged above along costa with a blackish line. Fringe double, of the ground color, the denser scales of the basal series pale-tipped, forming a submedial line. Hind wing gray, with a tawny shade in base of fringe. Head, thorax and fore wings with marked violet iridescence.

Genitalia as figured.



Trichotaphe iothalles, side view, holotype

Æd.—Ædæagus

Ann.—Annellus

Gn.—Gnathos

J.—Juxta (ventral portion of
annellus)

Sac.—Saccus

Soc.—Socius

Teg.—Tegumen

Tn.—Ental extension of valve,
serving as a tendon

U.—Uncus

V.V.—Upper and lower lobes of
valve.

Slide by August Busek, in U. S. National Museum. Drawing by May Gyger.

Holotype, New Brunswick, N. J., Aug., 1932, in U. S. National Museum; paratypes from Locust Valley, Long Is., N. Y., reared from red oak (Latham), Orient and Riverhead, Long Is., (Latham); Yonkers, N. Y., (Klots); Green Village, N. J., (Rummel); and Ramsey, N. J. The material from Long Is. was studied through the courtesy of Mr. Roy Latham, the rest through Dr. A. B. Klots and the authorities of the American Museum of Natural History. The paratypes will be divided between the National Museum, the Cornell Museum and the sources.

I know no close relatives of this species. In Busck it will key out at no. 15 by the warm yellowish ground, in my key it differs from *T. trimaculella* by the contrasting dark borders and much larger size; in the European fauna (Hering's key in the Tierwelt Mitteleuropas) it differs from *Brachmia rufescens* again by the contrasting dark borders and free R_3 . *Brachmia* also feeds on grasses.

BOOK NOTICE

A Catalogue of the Original Descriptions of the Rhopalocera Found North of the Mexican Border, . . . Bulletin of the Cheyenne Mountain Museum, Colorado Springs, Colorado, Vol. 1, Part 2, The Satyridæ by Cyril F. dos Passos. April 20, 1939.

We note with pleasure the publication of the second part of this very greatly needed catalogue of North American Butterflies, the first part of which has already been reviewed in this JOURNAL. A number of desirable changes in typography and arrangement contribute very materially to the usefulness of the work. It might be suggested, however, that in the citation of genotypes the original genus and the date of publication of the type species be included. Also it would seem well to introduce uniformity in the matter of placing the name of the author in parentheses when a species is cited in a genus other than the original one. In the present list this has been done with names regarded as valid, but has not been done with most of the names placed in the synonymy. Taxonomically the work seems excellent. We might prefer to have seen a bit more "lumping" as a means of indicating relationships, such as the case of *Minois pegala*, *alope* and *ariane*, but such matters are very largely personal preference. On the whole this part shows great improvement and sets a high standard that we hope will be equalled by the issues to come.—ALEXANDER B. KLOTS, College of the City of New York.

A CONTRIBUTION TO A BIBLIOGRAPHY FROM 1909 TO 1936 OF HENRY DAVID THOREAU

BY J. S. WADE

INTRODUCTION

It is the purpose of this compilation to assemble references to publications by or pertaining to Henry David Thoreau (1817-1862), American naturalist, writer, teacher, lecturer, ethnologist, poet, and philosopher, which references would form a contribution to his bibliography to supplement those already published. Particularly it is desired to make additions where necessary to the very excellent bibliography by Francis H. Allen, published in 1908 and, insofar as possible, it is intended to bring his bibliography from that date down to Dec. 31, 1936.

While no pains have been spared to give full bibliographical data in every citation, this has not always been possible. The occasional lack of full information, such as name of publisher, pagination, etc., accompanying some of the references, was due to the impossibility of making an actual physical check of the given item. Regrettably, these omissions became so numerous as almost to change portions of the compilation to a check-list status. No one realizes these obvious imperfections more clearly than does the compiler but "the field has been broad, the difficulties have been many, and the compiler lays no claim to perfection."

It may be noted that there are included in this bibliography a considerable number of references to publications, the main subject matter of which does not deal directly with Thoreau, but, which incidentally may contain much important discussion concerning him. Examples of this are the biographies of Thoreau's contemporaries, or the references dealing with localities and such like identified in some way with his career. References of this kind of course might be greatly multiplied and their comparative value, with that of others of a similar kind which have been omitted, might reasonably be brought into question. However, the included items of this kind are such as the compiler has deemed of sufficient usefulness to students as to justify their

inclusion, since some of them contain subject matter not elsewhere presented.

The preparation of this bibliography might well be considered as a labor of love, motivated by a personal interest in Thoreau's life, teachings, and philosophy. The references herein have been brought together one by one over a period of some 27 years as opportunity offered in course of other studies in various libraries. Since the accumulation of these references was largely a matter of recreation, there was no thought of ultimate publication until the usefulness of the compilation to other students of Thoreau was pointed out and realized.

In this connection it is a pleasure to acknowledge favors extended by other students of Thoreau's writings, notably Dr. Raymond Adams of the University of North Carolina and Mr. Francis H. Allen, formerly on the editorial staff of Houghton Mifflin Company, Boston, both of whom were good enough to review critically the manuscript of the compilation, to supply additional references and to make suggestions of much helpfulness. Grateful acknowledgement also is gladly made for courtesies extended by the officials of the libraries of Harvard University, Boston Society of Natural History, Johns Hopkins University, Peabody Institute, University of Pennsylvania, Carnegie Institute of Pittsburgh, Field Museum of Natural History, John Crerar Library, New York Public Library, and others. Especial thanks are due to those connected with the various great libraries of Washington, notably, that of the United States Department of Agriculture, the Smithsonian Institution, and most of all the Library of Congress, that Mecca of American students, where most of the actual checking and completion of citations was performed during evenings and spare time supplementary to other reference work.

Thoreau was one of those individuals who remained comparatively unknown and unappreciated during his life time, but, who attained worldwide and steadily growing fame after his death. As Bradford Torrey once put it: "The fathers neglected him . . . and the children garnished his sepulchre. Fame is a plant that blossoms on graves; as a manual of botany might say, a late flowering perennial nowhere common, to be looked for in old

cemeteries." An excellent scale by which to measure something of the growth and permanence of Thoreau's fame, during the 75 years since his death, is to examine and to evaluate the output of published matter, by or concerning him, which has accumulated during that period. Because of his delayed recognition the very considerable total of the references in all the bibliographies concerning him which cover these decades, take on an added and touching significance to those who love his writings and who revere his memory.

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Said Holbrook Jackson concerning Thoreau: "The most remarkable incident in the wilful endeavors of Thoreau was his Walden experiment, which, if it had no further results, has produced one of the most delightful books, even from the merely literary point of view, in the English language. For Thoreau coupled the high seriousness of an unique and picturesque personality with a rare and felicitous gift of vigorous prose, and he was the master of sly wit with an ironic sting in its tail. . . . His method of interpreting his idea of life is such that one is not so much dominated by its author's personality as put into more intimate relationship with one's own. Few of the readers of 'Walden' want to become hermits, but it is conceivable that often reading it they may want to become themselves, and possess some knowledge of how to carry out the wish. . . . He stood for a soul freed from the necessity of doctrinal upholstery. He possessed the spirit of a boy, backed by the wisdom of the ages, and he learned to taste all the stars and all the heavens in a crust of bread."

BOOK NOTICES

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Sometimes I wonder if the children of entomologists take any interest in entomology and if they receive any encouragement from their parents. I also wonder if entomologists are started off early in life by reading, by instruction, or by accident. Whatever the answers may be, and whether one is an entomological parent or not, the three books listed above are, I believe, excellent ways in which to introduce entomology to children. Whether the inoculation is successful or not, by this or any other method, will have to be left to chance. However, I do not believe the authors have set out deliberately to train children into entomologists. After reading their accounts, I am inclined to think that they became so enthusiastic about insects and allied creatures that they couldn't help bursting into prose about them.

Many, many years ago the few books on entomology for children were either plain misstatements of facts or didactic moral tales about insects after the manner of Maria Edgeworth. Such characteristics are missing from the books by King and Pessels. These authors have taken our common insects, spiders and other garden creatures and have written about them in an easy, flowing style, which is both interesting and readable, and which is sure to appeal to young people. They have personalized their subjects and have presented the interesting parts of their lives and habits in such a way as to make them appear to be friendly creatures living with us as neighbors, which indeed they are. At the same time they have kept their entomological facts correct and have not dramatized insects into something which they are not.

Butterflies, "tumble bugs," "lady birds," bees, ants, dragonflies, katydids, Japanese beetles, termites, earwigs, water bugs,

snails, spiders, toads, earthworms and other small creatures parade through the pages of these three books in delightful disorder and in a manner sure to appeal to the curiosity of youthful students of natural history. And the numerous illustrations, which play an important part in making the books interesting, are much better than many found in our solemn books on entomology. In fact, I don't see how they could be improved. As a rule, I have little enthusiasm for natural history books for beginners, but these three are interesting and attractive, and deserve to be read and treasured.—H. B. W.

The New York Entomological Society

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

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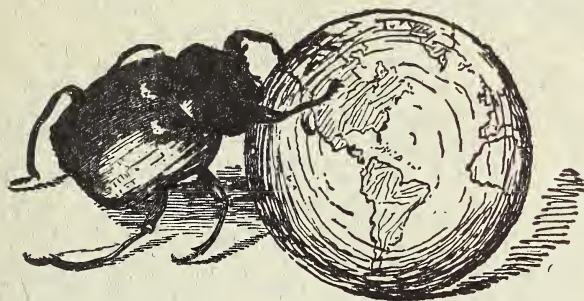
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No. 3

CICADAS COLLECTED IN THE CAYMAN ISLANDS BY THE OXFORD UNIVERSITY BIOLOGICAL EXPEDITION OF 1938

BY WILLIAM T. DAVIS
STATEN ISLAND, N. Y.

Through the courtesy of the Oxford University Biological Expedition to the Cayman Islands, 1938, I have been able to examine 92 cicadas collected on the three Cayman Islands, south of Cuba by C. Bernard Lewis and Mr. G. H. Thompson from April 26 to August 23, 1938, and Mr. Lewis has furnished many field notes.

In the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, March, 1930, p. 61, the writer described and figured *Diceroprocta cleavesi* from a single male collected on Grand Cayman, April 17, 1929, by Howard H. Cleaves of Staten Island. In 1930 and 1931 twenty-eight additional specimens were received from Grand Cayman, and the female of *cleavesi* was described in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, June, 1932, p. 246.

With the aid of the 92 specimens collected in 1938 from all three of the islands, it is found that each of them has an endemic form separable from the others by a combination of characters. They are naturally closely related. They are also related, but separable from *Diceroprocta biconica* Walker, described from Cuba in 1850, and from *Diceroprocta bonhotei* Distant, described from the Bahamas in 1901. The chief difficulty arises in separating the females from Grand Cayman and Little Cayman, but it can be done, usually on color differences.

SEP 21 1939

It is of course important that more collecting be done on the Cayman islands, as additional specimens from different broods found in future years may modify the conclusions here expressed.

In a recent communication, Mr. Lewis states that the two cicadas in the Distant Collection, British Museum, referred to in the original description of *Diceroprocta cleavesi*, 1930, probably came from Cayman Brac, as a label on the male determined by Distant as *biconica* Walker, gives that island as locality. In *Genera Insectorum*, Plate 4, Figure 24 there is shown a male with expanse of wings of 85 millimeters. All of the cicadas from the three Cayman Islands expanding 85 millimeters, have the front wing noticeably narrower than in figure 24, namely 12 millimeters instead of 14.

Grand Cayman

Diceroprocta cleavesi Davis

As already noted *cleavesi* was described from this island in 1930 and further mentioned in 1932. We quote from Mr. Lewis' field notes of 1938: "The first cicada to be taken on the island was secured in Georgetown on April 26, on which day several others were heard. No large emergence was noticed at any time during our stay from April to September. The specimens were all taken on the north side of the island or along the west coast and as I recall, none were seen or heard at the east end or along the south coast. The insects became fairly numerous on the bluff behind the town of North Side about the middle of July; previous to that time few individuals had been noticed. Many of the specimens taken at West Bay came to the light traps."

Thirteen males and 12 females were collected on the island in 1938, the first, a male on the 26 of April, and the last, also a male, on the 23 of August.

In *cleavesi* the males have the base, sides, and extremity of the abdomen pruinose, leaving centrally an ovoid brown colored area. The females lack this ovoid area, but have the abdomen edged with white, leaving a very much broader, brown area than in the males and of a different shape. In the original description of *cleavesi* the deep orange color found at the base of the

wings was noted, instead of the greenish color as in *bonhotei* and *biconica*. Most of the 1938 specimens are orange at or near the base of all of the wings; others have the costal margin of the fore wings green, paler at the base. Several of these are teneral specimens. On this island, judging from the material at hand, the males and females differ more from each other in color pattern than on the two other islands. On the pronotum of *cleavesi* there is a noticeable black spot each side of the green brown or orange collar. The wish-bone shaped uncus, when exposed and viewed from the rear, is seen to be black or nearly so, and much darker than in the males from the two other islands.

Little Cayman

Diceroprocta caymanensis Davis

We quote from Mr. Lewis' field notes: "On June 6, 1938, the form appearing on this island was found in great numbers in a very small area about a half mile inland from the extreme east end of the island. A few plantations were kept in this region but no one lived there. The swarm was located on the edge of a freshly burned patch. At ten o'clock the trees for about fifty square yards were filled with them and the situation reminded me of the swarms of Brood X of *Magicicada septendecim* which I witnessed in Baltimore, Maryland, in 1936. It was difficult for our party to converse, the males produced such a din. The species was to be found in limited numbers all over the eastern part of the island but no where else was a swarm discovered. A few scattered individuals were heard in the western part of the island but they were rare. The males of this form have a white transverse band, dorsally, at the base of the abdomen which is lacking in the female." Though careful search was made by Mr. Lewis and Mr. Thompson, they were unable to discover any nymphal cases even in that part of the island occupied by the swarm.

In the species occurring on Little Cayman, the male, in coloring approaches more closely *biconica* and *obscurior* of Cuba, than it does the males of the two other islands.

Diceroprocta caymanensis new species (Plate I, Figs. 5, 6)

Type male and allotype female, from Little Cayman Island, 7 June, 1938 (C. B. Lewis and G. H. Thompson). To be placed in the British Museum.

Resembles in size and general appearance the darker colored *D. obscurior* of Cuba, but the front of the head is more prominent. In form of head and general color it resembles more nearly the larger *D. biconica*, also of Cuba, but differs in pruinose pattern. (See descriptions and figures, JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, June, 1935.)

Eyes prominent and not quite as broad across the head as across the collar. Opercula triangular, nearly reaching the fourth abdominal segment, with sides slightly converging near the obtusely pointed extremities. In some of the paratypes the outer sides of the opercula are more nearly parallel to each other. Terminal dorsal spine of the last abdominal segment of the female short and with a slight upward bend. Head and pronotum brown, variegated with black as in *cleavesii* and *ovata*; collar green or greenish and usually without the black spot each side, noticeable in most specimens of *cleavesii*. The four obconical spots reaching backward from the front margin of the mesonotum strongly marked. Cruciform elevation and hind margin greenish. Tymbal covers generally paler than the central dorsal area of the abdomen, and connected in the male by a pruinose area containing two prominent white spots. Abdominal segments with hind margins greenish, and a dorsal blackish stripe about 4 millimeters broad (sometimes faintly represented) with the sides nearly parallel. Each segment near the central part of the abdomen, has, at the sides, a dark spot sometimes but faintly represented. The dorsum of segment 8 almost entirely pruinose in male, reduced in the females to two prominent white dots. The wish-bone shaped uncus is pale and not black as in *cleavesii*. Beneath pale, the opercula straw color; abdomen strongly pruinose at sides, leaving a broad light-brown central stripe; valve pale brown. Fore wings with the costal margin green to end of radial area, darker beyond; first and second cross veins infuscated; venation pale at base and darker about the marginal areas. Greenish at base of all of the wings, sometimes faintly orange, with the anal membranes gray and much paler than in *obscurior* of Cuba.

Measurements in Millimeters

	Male	Female
	Type	Allotype
Length of body	30	28
Width of head across eyes	12	12
Expanse of fore wings	94	93
Greatest width of fore wing	13	12.5
Greatest length of operculum	8	

In addition to the type and allotype 13 males and 19 females were collected on Little Cayman from 29 May to 7 June, 1938. The 12 in alcohol have lost much of their green color, and are browner than those not so treated.

Cayman Brac

Diceroprocta ovata Davis

We quote from Mr. Lewis' field notes: "Cicadas seemed to be generally distributed over the island but were most numerous on the bluff at the east end of the narrow land mass. Here they were emerging in large numbers toward the end of May. Nymphal cases were commonly found clinging to the trees and nymphs were always to be found on the roots of any plant that might be pulled up for examination. The natives complained of much damage done in this region by these insects, especially to the Cassava. Males and females were equally common, but owing to the greater alertness of the males we seem to have more females. These insects had to be caught by hand and since the footing in this region is particularly bad this was not an easy task and the individuals were often disturbed before they could be reached. Both sexes show wide lateral white areas along the abdomen, which in the males meet anteriorly."

It is of much interest that while Cayman Brac is less than six miles east of Little Cayman, that the cicadas should be so differently marked from those on that island. Neither sex is marked as in *caymanensis*, nor the allied forms from Cuba, as far as at present known.

***Diceroprocta ovata* new species (Plate I, Figs. 7, 8)**

Type male, east end of Cayman Brac, Spot Bay, 24 May, 1938, and Allotype female from same locality, 25 May, 1938 (C. B. Lewis and G. H. Thompson). To be placed in the British Museum.

This species is like *D. cleavesi* and *D. caymanensis* in structure characters, but differs from each in quite obvious and important color characters. From both of them it differs in having the sides of the abdomen in both sexes heavily and widely pruinose, leaving a large, oval, chocolate colored central area. In *cleavesi*, from Grand Cayman, only the male is thus colored, while in *caymanensis* from Little Cayman, neither sex has the broad pruinose areas. The anal membranes at the base of the hind wings are pure white in *ovata*; in the other two forms they are gray. In *ovata* the sides of the pronotum are often pruinose close to the eyes, which is not the case in the other forms. The black spot each side near the anterior angles of the greenish collar is small and sometimes absent. It resembles *caymanensis* in not having individuals with the venation noticeably orange as in many specimens of *cleavesi*. The wish-bone shaped uncus is pale as in *caymanensis*, and not black, as in *cleavesi*.

Measurements in Millimeters

	Male	Female
	Type	Allotype
Length of body	31	29
Width of head across eyes	12	11.5
Expanse of fore wings	94	95
Greatest width of fore wing	13	13
Greatest length of operculum	9	

In addition to the type and allotype 14 males and 17 females were collected on Cayman Brac by Mr. Lewis and Mr. Thompson from 18 to 28 May, 1938. They were found both at the east and west ends of the island and at Stakes Bay on the north coast a male and a female came to the light-trap.

PLATE I

- Figure 1. *Diceroprocta cleavesi* Davis, 1930. Type.
 Figure 2. *Diceroprocta cleavesi* Davis, Underside of Type.
 Figure 3. *Diceroprocta cleavesi* Davis, Male, Grand Cayman.
 Figure 4. *Diceroprocta cleavesi* Davis, Female, Grand Cayman.
 Figure 5. *Diceroprocta caymanensis*, Type. Little Cayman.
 Figure 6. *Diceroprocta caymanensis*, Allotype. Little Cayman.
 Figure 7. *Diceroprocta ovata*, Type. Cayman Brac.
 Figure 8. *Diceroprocta ovata*, Allotype. Cayman Brac.



THE ENTOMOLOGY OF THOMAS BOREMAN'S POPULAR NATURAL HISTORIES

BY HARRY B. WEISS

It is difficult, on this side of the Atlantic, to accumulate sufficient information about Thomas Boreman and his natural history books, for an adequate account. Nevertheless, because he has been omitted from entomological bibliographies, it seems desirable to take some notice of him, even at this late date.

According to the British Museum Catalogue there is attributed to Thomas Boreman a work entitled, "A Description of three hundred animals: viz. Beasts, Birds, Fishes, Serpents, and Insects: With a particular account of the whale-fishery: extracted out of the best authors. . . . Illustrated with copper plates. London, 1730." Considering the numerous later editions, it must have had a considerable degree of popularity. There is a copy of the third edition, 1736, "printed for R. Ware," in the Harvard College Library.* The British Museum Catalogue lists a seventh edition dated London, 1753, and an eleventh edition in the John Carter Brown Library is dated 1774.

Following the success of what was apparently the first edition in 1730, a supplement was brought out. I have not been able to locate a copy, but from notices in several of Boreman's works it dealt with "A Description of a great Variety of Animals and Vegetables: viz. Beasts, Birds, Fishes, Insects, Plants, Fruits and Flowers. Extracted from the most considerable Writers of Natural History; and adapted to the use of all Capacities, but more particularly for the Entertainment of Youth. Illustrated with above Ninety Copper-Plates, whereon is curiously engraven every Animal and Vegetable described in the whole Book." This supplement went into a second edition and there may have been more. According to an advertisement in one of Boreman's works, this supplement covered accounts of forty-nine "curious" insects, including the silk worm, the "tarantula spider, whose bite causes a melancholy madness, that nothing but a merry tune will relieve," the ant, and the "blue-fly."

* This Library also has copies of the 1812 and 1829 editions.

In 1739, there appeared, "A description of some curious and uncommon creatures, omitted in the description of three hundred animals, and likewise in the supplement to that book, designed as an addition to those two treatises, for the entertainment of young people. Compiled by the same hand. In which is included, the natural history of those great curiosities, the chimpanzee, male and female, brought from Angola, on the coast of Guinea, and lately publicly shown in London. Illustrated with sixteen copper-plates, whereon is neatly engraven the figure of each animal. London: Printed for Richard Ware, at the Bible and Sun in Amen-Corner: and Thomas Boreman bookseller in Guildhall. MDCCXXXIX." This book (16 × 10 cm. p. [i-iv.] 1-88 [i-iv]), first shown to me by Mr. Wilbur Macey Stone, aroused my interest in Boreman by reason of its entomological accounts on pages 59 to 67.

The three foregoing titles, in which Boreman had a hand, were all that I could locate relating to natural history. From the John Carter Brown Library, I obtained photostats of the entomological portion (p. 201-213) of "A Description of Three Hundred Animals, viz. Beasts, Birds, Fishes, Serpents, and Insects. With A particular Account of the Manner of their Catching of Whales in Greenland. Extracted from the best Authors, and adapted to the Use of all Capacities. Illustrated with Copper-Plates, whereon is curiously engraven every Beast, Bird, Fish, Serpent, and Insect, described in the whole Book. The Eleventh Edition. Carefully corrected and amended. London: Printed for J. and F. Rivington, Hawes, Clarke and Collins, T. Caslon, S. Crowder, B. Law, F. Newbery, G. Robinson and H. Baldwin. MDCCCLXXIV." Although this was published forty-four years after the 1730 edition, I doubt if the corrections and changes were really extensive.

In this eleventh edition, the entomological portion, under the heading, "A Description of Insects," deals with relatively few insects. There is a general statement about caterpillars. "Some of them are rough, hard, and stiff; some are soft, smooth, and tender; some horned either in the Head or Tail; others without Horns; all have many feet." And in addition there are such statements as,—"The Butterfly is the Insect in Perfection; the

Caterpillar, Grub, or Worm, are certain Mimicks, or Disguises of it for a Time, in which one and the same Animal is circumvested by Nature, for various Uses, viz. with the Disguise of a Caterpillar, that it may eat this or that food; but of a Grub or Worm, that its joints may be finished or hardened." Apparently the "grub or worm" refers to the pupal stage. The entire caterpillar account consists of less than two pages and is so general as to be worthless except to a very, very general reader.

The next insect is the louse, and in old popular writings on insects, this creature was always treated with a certain amount of levity. The present book is no exception. According to it, "The Louse is a Creature so officious, that it will be known to every one at one Time or other; so busy and so impudent, that it will be intruding itself in every one's Company; and so proud and aspiring withal, that it fears not to trample on the best, and affects nothing so much as a Crown, feeds and lives very high, and that makes it so saucy, as to pull any one by the Ears, that comes in its Way, and will never be quiet till it has drawn Blood; it is troubled at nothing so much as at a Man that scratches his Head, as knowing that Man is plotting and contriving some Mischief against it, and that makes it oftentimes skulk into some meaner and lower Place, and run behind a Man's back, though it go very much against the Hair; which ill-conditions of it have made it better known than trusted." This opening statement is followed by some descriptive matter which is valueless. For example, "the Head seems very round and tapering, ending in a very sharp Nose, which seems to have a small Hole, and to be the passage through which he sucks the Blood."

The remaining creatures are the flea, honey bee and scorpion and the account of the honey bee occupies most of the text. Accompanying the entire account are four full-page, crudely drawn illustrations of insects and of a bee-hive.

The entomology of "A description of some curious and uncommon creatures, omitted in the description of three hundred animals, and likewise in the supplement. . . .," London, 1739, is with one exception of the same general brand. This book includes travelers' accounts of the ravages of "locusts," passages from the Bible, and "the natural history of the Ephemeron."

This latter account, which is the best of the lot, was taken, sometimes with little change in wording from "*Ephemerī Vita: or the Natural History and Anatomy of the Ephemeron*. A fly that lives but Five Hours. Written Originally in Low-Dutch by Jo. Swammerdam, M.D., of Amsterdam. London. Printed for Henry Faithorne, and John Kersey, at the Rose in St. Paul's Church-yard, 1681," a translation by Edw. Tyson, M.D. Then there are moral reflections on the short life of the Ephemeron from various authors. The illustrations, as usual are crude and in some instances, terrible.

If Thomas Boreman had anything to do with these books, he was, in all probability, a compiler, one without much discrimination, because he put together observations, mistakes, worthless descriptions, etc., of naturalists, travelers, etc., as recorded in previous works. If anything good is included, it probably slipped in by mistake, and not because of the compiler's nice perception. Boreman was interested in sales. These in turn depended upon "reader interest," and like the average modern journalist, Boreman was concerned with the unusual, the strange, the grotesque, etc., rather than with sober facts, although it must be admitted that during Boreman's time, natural history was full of fallacies and suppositions, which were repeated over and over. Even today we are not entirely free of them. Boreman's accounts of animals other than insects appear to be written in the same vein but no doubt his readers were charmed with the statements about the "male pygmy, or chimpanzee," the white bear, the mermaid, the hooded-serpent, the fishing frog, etc. Although his popularizations were in most cases written for "young persons," I believe that many older ones enjoyed them. The prices of his natural history books were quite reasonable, not going above three shillings. Richard Ware, with whom he was associated, published other popular books, such as dictionaries, Persian and Turkish tales, the natural history of English song birds, the young clerk's assistant, housekeeper's pocket book, etc.

Thomas Boreman had his place of business or bookstall "near the two giants in Guildhall," the seat of the government of the City of London, and his publishing activities were not confined

exclusively to natural history books, According to Mr. Wilbur Macey Stone, he issued a political pamphlet in 1735 entitled "The History of Intriguing," and while he has been neglected for many years and justly so by naturalists, his memory retains a certain amount of greenness among collectors of children's books for his achievement in bringing out his Gigantick Histories, a series of ten little volumes, $2\frac{1}{4} \times 1\frac{7}{8}$ inches, between 1740 and 1743. These miniature books for children, once deservedly popular and now exceedingly rare, covered such subjects as the history of the Guildhall Giants, the curiosities in the Tower of London, the history of the Cathedral of St. Paul's, Westminster Abbey, etc., all of which and much more are entertainingly and interestingly set forth by Mr. Wilbur Macey Stone in his book "The Gigantic Histories of Thomas Boreman," which was published in an edition of 250 copies by the Southworth Press of Portland, Maine, in 1933. In conclusion, I might say that I regard Mr. Boreman more highly for his Gigantic Histories than for his natural histories.



BOOK NOTICE

The History of Entomology at the Massachusetts Agricultural College, 1867-1930. By Henry T. Fernald. Fernald Club, Special Publication Number 1, Massachusetts State College, Amherst, Massachusetts. 1938. $10\frac{7}{8} \times 7\frac{7}{8}$ inches. 55 sheets mimeographed on one side. Printed cover page.

Personally, I first became aware of the Massachusetts Agricultural College through Mrs. M. E. Fernald's "Catalogue of the Coccidæ of the World," published in 1903. And since that time I have always held a high opinion of the entomological work and of the entomologists turned out by that institution.

The present history, by Dr. Henry T. Fernald, now supplies a concise and orderly account of the development of entomology at Amherst over a period of 64 years. These are divided into four periods, the first from 1867 to 1886, at which time Professor C. H. Fernald joined the staff; the second from 1886 to 1889, when organized graduate work was started; the third from 1899 to 1910, when Professor C. H. Fernald retired, and the fourth, from 1910 to 1930, when Dr. H. T. Fernald retired.

The account starts with the early lectures on entomology by the president and others, including A. S. Packard, Jr., and traces the growth and development of entomological work almost to the present time. This interesting record is concerned with the various types of entomological courses and activities, new pests, new buildings, experimental work, testing of insecticides, publications, and the lines of entomological work for which Amherst has become noted. In addition there is included a list of students who selected entomology as their life work and this contains the names of many who will immediately be recognized as outstanding entomologists. A brief appendix by Dr. C. P. Alexander bridges the period from 1930 to 1932.

Dr. Fernald's history is a welcome and valuable addition to the slowly growing body of facts about the history of entomology in America.—H. B. W.

SEROLOGICAL INVESTIGATION OF *DROSOPHILA* ANTIGENS USING THE PRECIPITA- TION REACTION

BY SOL HABERMAN AND RUSSELL W. CUMLEY

DEPARTMENT OF ZOOLOGY, THE UNIVERSITY OF TEXAS, AUSTIN

INTRODUCTION

The purpose of this investigation was to determine whether the precipitation reaction can be used in differentiating antigens of various *Drosophila* species. In an earlier study the complement fixation reaction was employed (Cumley and Haberman). The antigen-antibody relationships, determined by the two methods, were not found to correspond exactly when computed on a percentage basis. The order of reactivity of a series of antigens to a given antiserum, as determined by the two technics, was found to be much the same. The data presented in either of these preliminary reports do not warrant a final conclusion regarding the antigenic relationships existing between the species of *Drosophila* investigated.

MATERIALS AND METHODS

Since, at present, there is no information regarding the specific fractions of the *Drosophila* antigens, no attempt was made in either this investigation or in the previous one to remove fractions soluble in ether, alcohol, or chloroform. The saline extracts, standardized in terms of their nitrogen contents, were employed as antigens. This method may find objectors, since the antigenic components of certain bacteria are known to be alcohol soluble. On the other hand, a highly specific alcohol-insoluble substance has been isolated from moth tissue (Martin & Cotner, 1934). Several competent workers have insisted that the precipitin test is lipid sensitive, and that the lipoids must be removed from the antigen before accurate specific differences can be obtained (Becker, 1932; Boyden, 1936; Moritz, 1934). Hence, there was no means of anticipating which fractions of the *Drosophila* contained the antigenic principles. Immunization of the rabbits has been reported in the previous experiments.

The "ring test" of Ascoli was applied in the manner used by Fornet and Muller (1910), because it gave easily readable results and required small quantities of reagents. Several minor modifications were made in order to adapt the test to the problem in hand. The precipitin tubes were 6 mm. in outside diameter and 40 mm. in length. Capillary pipettes were used for layering the antigen over the antiserum. In the tests about 0.2 cc. of undiluted serum was placed in each of ten tubes by means of capillary pipettes. Ten dilutions of antigen were prepared, varying from 1:50 to 1:1200. These dilutions were made from the original saline extracts that had been standardized in terms of nitrogen content. The original extracts were themselves 1:50, and consequently for the first tube, they were not diluted. About 0.2 cc. of each antigen dilution was layered over the antiserum in each tube. Care was taken to prevent mixing of the two reagents at the serum-antigen interface. Serum-saline and antigen-saline controls were set up and incubated with the tests at 37 degrees Centigrade. The tests were read after one and three hours. The formation of a precipitate at the interface indicated a positive test. The tubes in the dilution series were read for amounts of precipitation and recorded in terms of plusses. The strongest ring reactions were indicated by four plusses (++++), the weakest by one plus (+), and the negative reactions by a minus (-).

RESULTS

Readings taken after one hour of incubation revealed definite rings of precipitation, but titres were low and irregular upon retesting. After three hours, higher and more regular titres resulted, and these were the readings which are presented in this report. Occasionally, by the end of three hours, the precipitate had begun to diffuse throughout the serum. End-points of reactivity occurred in antigen dilutions of from 1:50 to 1:1200.

In Table 1 are shown the results of tests in which a given antiserum is tested against its homologous antigen and several heterologous antigens. The *Drosophila* species are arranged in the order of the relative reactivity of their antigens to a given antiserum. Two antigens that are adjacent in any given test are not necessarily similar. Their respective positions are merely indicative of the

TABLE 1

[illegible]

reactivity of each to the serum in question. As in the case of the complement fixation reactions, there is considerable variability in the antisera of the rabbits immunized to the same antigen.

Table 2 presents the antigen-antibody relationships that have been calculated from the data of Table 1. The values were calculated on the basis of the highest dilution of reactivity as suggested by Boyden (1926, 1932, 1934), and on the basis of the total number of plusses, *i.e.*, the strength of reactivity, as suggested by Nelson and Birkeland (1929). These computations reveal the degree of reactivity between a given antigen and antibody, when compared with the homologous antigen-antibody reaction. The value of this work in the differentiation of species specific substances cannot be postulated at the present time.

TABLE 2

Type of Antiserum	Type of Antigen	Percentage Antigen-Antiserum Relationship: highest dilution of reaction (Boyden)	Percentage Antigen-Antiserum Relationship: total number of plusses (Nelson & Birkeland)
Mulleri	Mulleri	100.0	100.0
	Virilis	50.0	77.1
	Hydei	45.8	57.1
	Caribbea	22.9	22.4
	Bipectinata	13.1	18.8
	Melanogaster	Less than 6.3	Less than 7.2
Virilis	Virilis	100.0	100.0
	Mulleri	75.0	66.6
	Caribbea	50.0	55.6
	Hydei	37.5	51.8
	Bipectinata	12.5	7.4
	Melanogaster	.....	.....
Caribbea	Caribbea	100.0	100.0
	Hydei	41.7	48.5
	Melanogaster	29.2	49.1
	Bipectinata	25.0	52.2
	Virilis	25.0	44.8
	Mulleri	12.5	23.0
Melanogaster	Melanogaster	100.0	100.0
	Caribbea	66.6	91.0
	Hydei	50.0	59.1
	Mulleri	.....	.....
	Bipectinata	.....	.....
	Virilis	.....	.....

By comparing the data in Table 2 with those in Table 7* of the preceding complement fixation investigation, one may readily see that the antigen-antibody relationships, determined by the two methods do not correspond. The percentage relationship between any antigen and antibody is never quite the same in the two tables. The order of relationship however, of any series of antigens to a given antiserum is quite similar. Several authors have reported discrepancies of this sort, and the view was once held that two different antigen-antibody complexes were involved (Topley and Wilson, 1936, p. 166). More recently, however, these apparent inconsistencies have been attributed to the fact that the complement fixation and precipitation reactions are really the secondary results of a single antigen-antibody reaction, but that these results are obtained under different physical conditions. In the present case, either of these two causes may have given rise to the lack of agreement between the two tests. However, it is more likely that experimental error and inaccuracies of standardization will account for these discrepancies.

Exact reciprocal antigen-antibody relationships were not obtained, as may be seen in the data of Table 2. The same condition was observed in the complement fixation study. Although the suggestion has been made that reciprocal relations should exist between any two species (Boyden, 1934), there is considerable evidence that such a law is not universal. In the bacteria, results similar to those presented here have been obtained. There is a multiplicity of antigenic fractions in bacteria, and any sharing of these components will result in some reciprocal relationships. These shared components, however, are not always present in the same proportions in each of the species tested (Wilson and Miles, 1932). Thus it is that "a given dose of bacteria containing the antigens A and B in the proportions 3a plus 2b might remove all agglutinins from a serum containing the corresponding antibodies in the proportions 3A plus 2B; but the same dose of bacteria containing the same antigens in the proportions 2a plus 3b, while more than sufficient to remove all the B agglutinins, would leave some of the A agglutinins unabsorbed" (Topley, 1935, pp. 92-93). This condition would possibly account for the fact that several

* Jour. N. Y. Ent. Soc., vol. XLVI, no. 4, p. 412, Dec., 1938.

workers, using as antigens helminths (Eisenbrandt, 1936), wheats (Nelson & Birkeland, 1929), and molluscs (Makino, 1934) have failed to get strictly reciprocal values. Likewise, a sharing of antigens in unequal proportions is probably the reason for the lack of reciprocal antigen-antibody relationships among the *Drosophila* species.

CONCLUSION

The precipitation reaction has been used to show differences in the antigens of various *Drosophila* species. The values obtained by the precipitin test did not correspond exactly with those obtained by the complement fixation reaction, probably due to factors inherent in the two different technics or to errors in performing the tests. Reciprocal antigen-antibody relationships may or may not be found, depending upon whether the antigenic components of the various species are shared in equal proportions.

ACKNOWLEDGEMENTS

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DR. WALTHER HORN

The many friends of Dr. Horn, in this country, will be saddened by the news of his death which occurred at Berlin-Dahlem, on July 10, 1939, after much suffering. Dr. Horn was in his 68th year. He was cremated at Berlin-Wilmersdorf on July 15.

PHYSIOLOGY OF THE ARTHROPODAN CIRCULATORY MECHANISMS

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“... the circulation of the blood in insects is, in fact, incomprehensible if one supposes that the blood circulates as the result of propulsion by a positive pressure.”

—FRANCK BROCHER

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Circulation is necessary for the removal of accumulating metabolites from activated tissues; for a constant and adequate supply of buffers to local regions; for nutrition; for the prevention of an excessive localized rise or fall in osmotic pressure; and,

for the carriage of activating substances such as hormones and electrolytes. In arthropods whose blood has a significant respiratory function, the circulation of the blood is also of importance in the transportation of an adequate supply of oxygen to the cells and in the carriage of carbon dioxid from the vicinity of the cells to the respiratory organs. The circulation is of no appreciable respiratory importance in arthropods with a well developed tracheal system.

A. GENERAL ANATOMY

An exhaustive survey of the anatomical contributions to the heart is not attempted. Only important types are selected.

The circulatory system is characterized, except where it is degenerate or absent, by a dorsal muscular tube, or heart, provided with openings, or ostia, and usually extending anteriorly to the brain as the aorta. The ostia are often furnished with valves and are characteristic of arthropods. The heart does not have true chambers, each "chamber" of the elongated hearts being indicated solely by a swelling and by the ostial valves. The valves generally direct anteriorly and prevent a reflux of blood. In the larva of the ephemerid, *Cloëon* (Zimmermann, 1880), the posteriormost pair of valves direct posteriorly since the heart, instead of ending blindly at the anal end, as it does in most insects, gives off a single artery into each of the three terminal abdominal cerci. Posterior, lateral, and ventral arteries exist among the Crustacea and Arachnida and always open, often after extensive branching, into the body cavity, or hæmocœle.

"I have also observed," wrote William Harvey (1628), "that almost all animals have truly a heart, not the larger creatures only, and those that have red blood, but the smaller and pale-blooded ones also, such as . . . shrimps, crabs, crayfish, and many others; nay, even in wasps, hornets and flies, I have with the aid of a magnifying glass, and at the upper part of what is called the tail, both seen the heart pulsating myself and shown it to many others." This is the first record of the observation of a pulsatile vessel among arthropods.

The heart is always suspended from the integument by connective tissue fibers known as suspensory^o ligaments. A thin membranous sheet (the dorsal diaphragm or pericardial septum),

often fenestrated, containing cells and usually muscle fibers (alary muscles) extends from the ventral surface of the heart to the integument of the dorso-lateral regions, thus separating the pericardial from the visceral sinus. The dorsal diaphragm and its alary muscles were first described by Swammerdam (1669, pt. I, p. 136): "All along the course of the heart in the *Cossus*, similar moving fibers are likewise placed, which are inserted into the heart itself; and, they like so many different little ropes, expand and contract it." A century later, Lyonnet (1760) called the "appendages from the heart" of caterpillars the "Ailes du Coeur" but there is no evidence that he believed such to be muscular although one of his celebrated figures shows them as fibrous structures. Straus-Durckheim (1828), in an immortal work crowned in 1824 by the Royal Institute of France, called them the "oreillette." Dogiel (1877) christened the septum and its muscles the "diaphragm."

1. *Onychophora* (*Peripatus*). The heart, composed of unstriated and chiefly circular muscle fibers, is a long dorsal vessel running throughout the body length. It has segmentally paired ostia provided with valves. The fenestrated dorsal diaphragm has unstriated alary muscles which run transversely from the cuticle and spread fan-like towards the ventral surface of the heart. There are no arteries (Gaffron, 1885). In most other arthropods the heart and alary muscles are striated. In some insect larvæ the striations are at least not apparent (*cf.* Snodgrass, '35) and probably do not exist (Bergh, '02).

2. *Xiphosura* (*Limulus polyphemus*). The heart (Fig. 8) is elongated and lies in the cephalothorax. It has four pairs of valved ostia, *o*, a corresponding number of chambers, and four pairs of lateral arteries, *la*. Three arteries emerge at its anterior end and subdivide considerably. The dorsal diaphragm is muscled. Because of the large heart and extensive branching and ramification of the arteries (Dohrn, 1871; Edwards, 1872; Patten & Redenbaugh, 1899-'00), *Limulus* has a more highly developed circulatory system than any other arthropod.

3. *Scorpionidea*. The circulatory system of scorpions is very similar to that of their xiphosuran relative. The heart has seven pairs of valved ostia. In contrast to *Limulus*, there is a posterior

aorta in addition to anterior and lateral arteries. The anterior arteries subdivide and communicate with the perineural sinus supplying blood to the lung-"books," or hypodermal folds (Potts, '32).

4. *Araneida*. The heart of spiders has three ostia the largest of which, *i.e.* the anterior one, receives blood from the lung-"books." The posterior and anterior ends of the heart are each attenuated into an aorta. Three pairs of lateral arteries arise from the heart. At its anterior end the dorsal diaphragm forms a pair of open lateral veins through which the pericardial sinus receives aerated blood from the lungs (Causard, 1896; Franz, '03; Willem, '17).

5. *Acarina*. The single-chambered heart (Fig. 1, *h*) has two pairs of ventrally situated ostia and extends anteriorly as an aorta, *ao*. The aorta swells out into a large periganglionic sinus, *pg*, which completely envelops the much consolidated central nervous system, its nerve fibers, the oesophagus, *oe*, pharynx, *p*, and dilator muscles of the pharynx, *dp*. The musculature of the aorta is more sparse than that of the heart. The walls of the sinuses have no muscles. A dorsal diaphragm is absent but dilator muscles extend from the dorsal surface of the heart to the integument (Robinson & Davidson, '13). According to Edwards (1872), a somewhat similar condition exists in *Limulus*, the somatic nerves of which were described as travelling within the arteries.

6. *Tardigrada and Pentastomida*. These minute, free-living forms possess no circulatory or respiratory organs (Huxley, 1878, and Shipley, '09). Movements of the viscera suffice for the circulation of the clear colorless blood which, in tardigrades, evaporates during dry weather and is soon replaced during rain (Shipley). The small size of these animals renders special outfoldings, as extra surface for gaseous exchange, unnecessary owing to their relatively large surface mass ratio.

7. *Pantopoda (Pycnogonida)*. The heart runs from the level of the eyes to the abdomen. It has two pairs of lateral valvular ostia and sometimes an unpaired one at the posterior end. The fenestrated dorsal diaphragm extends into the distal extremities of the limbs (*cf.* Thompson, '09).

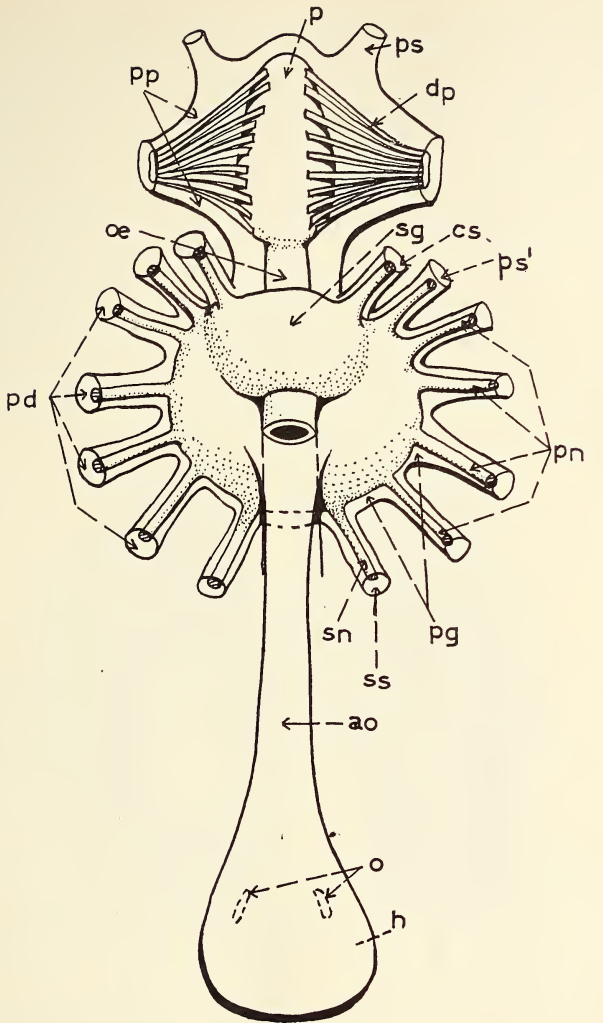


FIG. 1. Dorsal aspect of the circulatory system of the tick, *Argas persicus*, showing related organs. *ao*, aorta; *cs*, cheliceral sinus; *dp*, dilator muscles of pharynx; *h*, heart; *o*, ostium; *oe*, oesophagus; *p*, pharynx; *pd*, pedal sinuses; *pg*, periganglionic sinus; *pn*, pedal nerves; *pp*, peripharyngeal sinus; *ps*, *ps'*, palpal sinuses; *sg*, supraoesophageal ganglion; *sn*, splanchnic nerve; *ss*, splanchnic sinus. (After Robinson & Davidson.)

8. *Crustacea*. The Cirrepedia have no heart. The Entomostraca may have an elongated dorsal vessel with numerous pairs of ostia (e.g., *Branchipus*, *Apus*), or a sac-shaped heart with one pair of ostia (e.g., *Daphnia*) or no heart at all (e.g., *Cypris*). In the Amphipoda the heart is in the thorax and usually has three pairs of ostia. In the Stomatopoda the heart is in the abdomen and is an elongated vessel with several pairs of ostia (Delage, 1881, 1883). It is noteworthy, in this connection, that in the Amphipoda the *thoracic* appendages are transformed into gills while in the Stomatopoda the branchial tufts are borne on the *abdominal* swimmerets. In arthropods with blood gills or lung-“books” the heart is situated in the region of the body whence it can draw aërated blood from the vicinity of the gills as directly as possible.

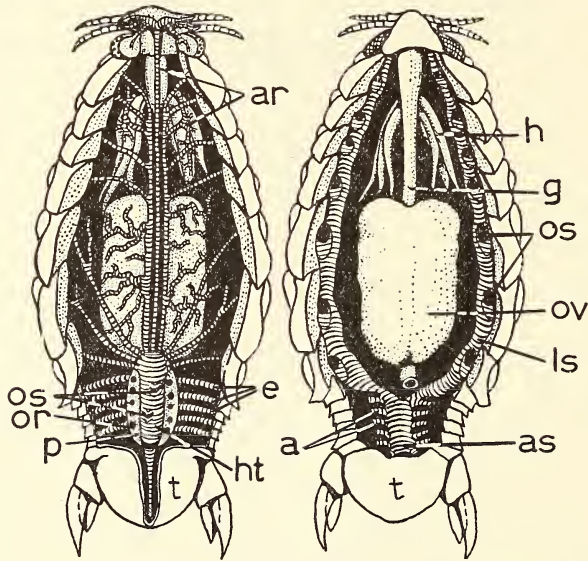


FIG. 2. The isopod *Anilocra mediterranea*. A. Arterial system with the dorsal aspect of the efferent branchial system; dorsal half of body wall removed. B. Venous system with the afferent branchial vessels; heart and arteries removed. *a*, afferent branchial vessels; *ar*, arteries; *as*, abdominal sinus; *e*, efferent branchial vessels; *ar*, arteries; *as*, abdominal sinus; *e*, efferent branchial vessels; *g*, gut; *h*, hepatopancreas; *ht*, heart; *ls*, lateral sinus; *or*, pericardial orifice of an efferent branchial vessel; *os*, ostia; *ov*, ovary; *t*, telson. (After Delage.)

The abdominally situated heart of isopods (Figs. 2 and 3, *ht*) sends several arterial branches anteriorly (Fig. 2A, *ar*) and one posteriorly. Into the otherwise closed dorsal diaphragm, open efferent vessels (Figs. 2A and 3, *e* and *or*) from the gills. There are five pairs of such vessels in *Anilocra mediterranea*. On the floor of the thorax and extending into the head are lateral sinuses (Fig. 2B *ls*) with large ostia, *os*. In the abdomen these sinuses are fused into a single median sinus (Figs. 2B and 3, *as*)

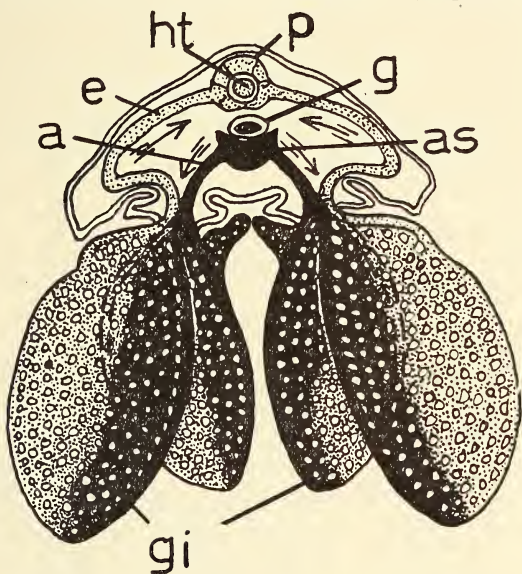


FIG. 3. The isopod *A. mediterranea*. Transverse cut through the abdomen. *a*, afferent branchial vessel; *e*, efferent branchial vessel; *g*, gut; *gi*, gills; *ht*, heart; *p*, pericardium. Arrows represent the direction of flow of the blood. The afferent stream is in solid black; the efferent is stippled. (After Delage.)

which gives off five pairs of afferent vessels, *a*, to the gills. The sinuses and branchial vessels are not mere blood streams but have definite limiting epithelia. There are spaces without tissues surrounding these vessels so that the cylindrical shapes of the vessels would not have been obtained upon the use of injections were it not for the presence of definite walls. The amphipods and læmodipods (*e.g.*, *Caprella*) do not have arteries in the limbs, as the isopods and schizopods do, but have sinus vessels instead.

Decapods (Fig. 6) and schizopods have branching arteries but no definite branchial or sinus vessels, the blood flowing through lacunar spaces. Although in all cases the heart is attached to the immediately surrounding tissues and dorsal integument by ligaments, it is, in the isopods and amphipods, completely enclosed by the dorsal diaphragm (Fig. 3, *p*). In the læmodipods, anisopods, decapods, and schizopods the dorsal diaphragm does not completely surround the heart but forms a ventral floor to such, as it does in the majority of arthropods. The dorsal diaphragm of the lobster extends into the gills (Fig. 6) as does that of the Pantopoda into the legs, that of the chironomid larvæ into the anal appendages (Fig. 4), and that of the amphipods, *Phronima sedentaria* (Fig. 5) and *Gammarus pulex*, into the locomotor appendages.

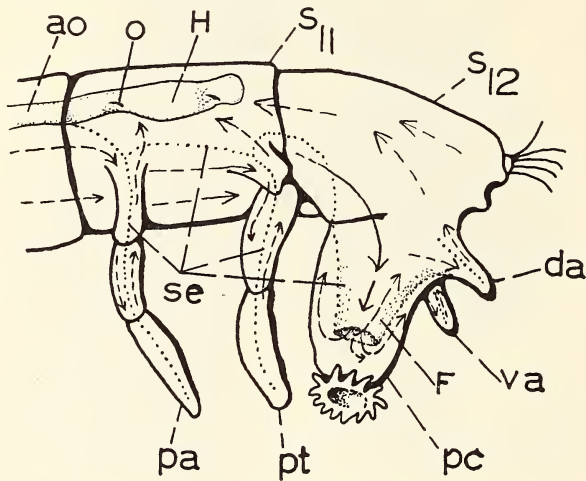


FIG. 4. Left side of the posterior region of the abdomen of a *Chironomus gregarius* larva. *ao*, aorta; *da*, dorsal anal appendage; *H*, heart; *O*, ostium; *pa*, anterior tubule; *pc*, posterior clasper; *pt*, posterior tubule; *S*, trunk segments; *se*, septa; *va*, ventral anal appendage. Arrows indicate the course of the blood. The septa are represented by dotted lines. (After Pause.)

9. *Chilopoda and Diplopoda.* The heart extends throughout the length of the trunk, having ostia in each definitive segment. The branches consist of lateral segmental arteries and an anterior

aorta. A pair of anterior arteries surround the gut and join ventrally to form the supraneural artery (Newport, 1843; Vogt & Yung, 1889-94).

10. *Hexapoda*. With the exception of a few Orthoptera and Apterygota (cf. Snodgrass, '35) the heart of insects is restricted to the abdomen where the major portion of the absorptive region of the alimentary tract lies. Since the oxygen capacity of insect

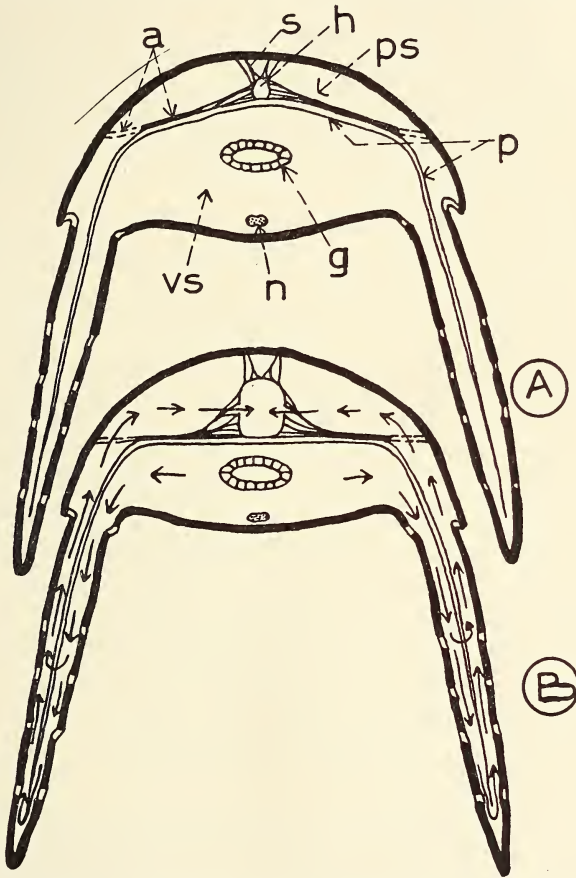


FIG. 5. Schematic transverse section through the thoracic segment of the amphipod *Phronima sedentaria*. A. With heart in the systolic phase. B. With heart in diastole. *a*, alary muscle; *g*, gut; *h*, heart; *n*, nerve cord; *p*, pericardial septum; *ps*, pericardial sinus; *vs*, visceral sinus; *s*, suspensory ligaments. (After v. Haffner.)

blood approximates that of water and may, in fact, be nil (Barratt & Arnold, '11; Bishop, '23; Florkin, '34), the circulation of the blood in these animals cannot be of much respiratory significance but is of nutritive importance. Hence the adaptive advantage of having the ostiated heart in a region as close as possible to the absorptive portion of the gut. The heart extends anteriorly as an aorta (non-ostiated) which often possesses circular muscles such as in the Heteroptera (Maluf, '33). Dorsal diverticula of the aorta occur in some Odonata, Orthoptera, Coleoptera, and Lepidoptera (Brocher, '20; cf. Snodgrass, '35). The heart of the water scorpion, *Nepa cinerea* (Hamilton, '31), yields two arteries posteriorly which pass into the muscles of the anal and genital armature. The aorta of the *Corethra* larva is contractile (Tzonis, '36).

The dorsal diaphragm is commonly arched upwards and generally contains muscle fibers. In the honeybee larva (Nelson, '24) it is apparently exceptional in possessing no muscles. These muscles are attached to the ventral surface of the heart and in some forms, such as *Nezara* (Maluf, '33), they cross over to the opposite half of the body. The septum of the dorsal diaphragm may or may not be fenestrated; but there is always a communication between the visceral sinus and the pericardial sinus through the lateral segmental openings. In *Chironomus* larvæ the septum of the dorsal diaphragm extends into the appendages at the posterior end of the trunk (Fig. 4) thus dividing the cavities of the appendages into channels for the inflow and outflow of blood. Pause ('18), probably erroneously, did not consider these septa as pertaining to the dorsal diaphragm and supposed the latter to be completely lacking. In the region of the posterior clasper, *pc*, the diaphragm septum extends as a funnel, *F*, the orifice of the funnel being, presumably, morphologically a fenestrum in the dorsal diaphragm.

The ventral diaphragm is not universally present but is well developed in acridid Orthoptera and the Hymenoptera (cf. Snodgrass, '35). In the grasshopper, *Dissosteira*, it extends from the head into the seventh abdominal segment. In the anterior part of the thorax it is a delicate membrane without muscles; posteriorly it has fine transverse fibers which attach laterally to the

integument and leave a series of intersegmental openings along the lateral margins of the diaphragm. It contains no cells other than muscle cells and apparently has no supporting membrane.

B. BLOOD PRESSURE AND CIRCULATION

In the early days of microscopical anatomy it was assumed that the "vital fluid" [blood] of the lower animals travels through veins and arteries as it invariably does in vertebrates. Malpighi (1669), the discoverer of the capillaries in vertebrates and hence, virtually, of the closed type of circulation, says this concerning the silkmoth caterpillar: "I have not as yet recognised for certain any arteries, containing the vital fluid, issuing from the heart; sometimes, in a pupa, remarkable segmental branches appeared to me, which I supposed to be arterial trunks." Swammerdamm (1669) believed he knew why he could not observe blood vessels in an *Ephemerus* larva: "No veins or arteries are seen in it for the blood of these insects is of a watery colour, and therefore does not distinguish the vessels containing it from the other parts." Concerning the honeybee larva he writes: ". . . the vessels in it, which carry and return the blood, are so very delicate and transparent, that I was not able to discern them." He injected the heart of a silkmoth larva by blowing a colored liquid into it through a fine glass pipette. "By these means, and then gently blowing into it, the heart and *many of the vessels shooting out from it* [italics mine] may be filled." "The vessels shooting out from it" may have been the tracheæ. Power (1664, p. 59) entertained similar opinions and speaks of the louse as having "a purple Liquor or Bloud, which circulates in her (as the Noblest sort of Animals have;) which though it only be conspicuous in its greatest bulk, at the heart, yet certainly is carried up and down in the Circulatory vessels; which veins and arteries are so exceedingly little, that both they and their liquor are insensible: For certainly, if we can at a Lamp-Furnace draw out such small Capillary Pipes of Glass that the reddest Liquor in the World shall not be seen in them (which I have often tried and done) how much more curiously can Nature weave the Vessels of the Body. . . ."

It was a time before zoologists could conceive of an open blood-vascular system. Thus, some of the best morphologists in Europe,

such as Audouin & H. M. Edwards (1827, 1827a), A. M. Edwards (1872), and R. von Hertwig ('00) believed that the circulation of *Limulus* and decapod Crustacea is closed. Even as late as 1911 Leontowitsch remarked that the circulation is the insect, *Ranatra*, and the shrimp, *Palæmon*, is closed although he stated: "Without microscopical preparations it is difficult to determine if these passage-ways (for the blood) are capillaries or merely body lacunæ." Identical observations had been noted by Leeuwenhoek (1688) on scorpions and crabs. Similar apologetic statements were made by Audouin & Edwards (1827) and Edwards (1872) as regards the "veins" of Crustacea and *Limulus*: "The walls of the vessels are of an excessive tenuity . . . only at their termination at the venous sinuses is it possible to recognise that they have an independent existence. . . ." They believed that the veins from the limbs enter the sinuses. Patten & Redenbaugh (1899-'00), in their classical work, could find no veins in *Limulus*. Lund (1825) was one of the first to state that decapod Crustacea possess no veins. In attempting to explain the manner of circulation in the limbs of insects, Louis Agassiz (1851), in a paper that became translated into French, stated that the notion that the tracheae are normally filled with air is only a relic of the times before William Harvey when men believed that undissolved air permeated the circulatory of vertebrates.

While Hertwig (*loc. cit.*) may not have implied a closed circulation in the morphological sense, he wrote that "the highly localised respiration implies an essentially (*nahezu*) closed blood system." In this he was right. Thus, by means of injection, Baron Cuvier (1805), one of the past master morphologists of Europe, found, in decapod Crustacea and a branchiopod (*Squilla*) that the blood leaves the heart to the different parts of the body; then to the large trunk sinuses; from the sinuses to the gills; and from the gills to the heart. He also showed that the blood entering the heart must first pass through the gills (hence the position of the heart in the vicinity of the gills and the fact that the pericardial diaphragm offers orifices only to the blood leaving the gills); that the blood can enter a gill solely by way of its ventral "vessel"; that the blood traverses the gill blade to its dorsal "vessel" and hence directly to the

heart (Figs. 3, 6, and 7). These results were confirmed by Audouin & Edwards (1827) and Plateau (1880). The former also showed that the ventral¹ "vessel" of a gill does not open into the heart but believed that the dorsal "vessel" does. They must, however, have mistaken the dorsal diaphragm for the heart, the description of the dorsal diaphragm of an arthropod appearing in print one year later (p. 229). Otherwise, their description is correct if the term *lacunæ* is substituted for "vessels." The significance of the aspirating action of the arthropod heart in drawing blood from the gills is now significant and is an excellent substitute for a double circulation and a heart which drives blood almost exclusively by propulsion. In the gills of the crab, *Maia* (Dubuisson, '28), there is only a 6 mm. of water difference between the blood pressure in the cephalothoracic visceral sinus and the pericardial sinus.

1. *Pressure.* When it became known that, among arthropods, the arteries open freely into the body cavity the problem of the mode of circulation through the narrow and elongated limbs became acute. In a closed blood-vascular system it is easy to see how blood can be kept in continuous motion solely by positive pressure. In mammals at least (Starling, '20, p. 946), expansion, *per se*, of the heart is a negligible factor in determining the rate of blood flow since the intraventricular pressure is never negative. Among arthropods the situation is quite different. "The mechanism of the circulation of the blood in insects," wrote Brocher ('31), "is, in fact, incomprehensible if one supposes that the blood circulates as the result of propulsion by a positive force. It becomes easy to understand once one realises that the flow of blood is the result of an aspiration and that in the body of insects this liquid is normally under a negative pressure." Brocher ('20, '31) has noted that, in general, the blood flow of insects is under negative pressure except in regions close to the orifice of the aorta. Contrary to what happens in animals in which the blood passes through definite vessels under a positive pressure, incisions through most regions of the integument cause either

¹ Their terms of "external" and "internal" for dorsal and ventral, used in this paper, apply only to arthropods with erect gills (Fig. 6) and not to those with dangling gills (Fig. 3).

no continuous hæmorrhage or no hæmorrhage at all. In many cases (*e.g.*, in leg stumps of a crayfish or insect) if a drop of water is placed on the wound the drop is drawn in. Both Hollande ('11, '11a) and Rabaud ('22) observed that the drop of blood which oozes out during the bleeding reflex of certain insects is frequently reabsorbed through the region of rupture.

On no account, however, should it be supposed that the blood pressure is always negative. Since arthropods have an open blood-vascular system, compression of the integument (produced by contraction of skeletal muscles) causes an augmentation of the blood pressure. Thus, the intra-abdominal blood pressure of dragonfly larvæ (Shafer, '23) shows abrupt changes (18–87 mm. of water) due to variations in the activity of the abdominal skeletal muscles. Molting is, partly in this manner, made possible. Inflation of the gut, either by the swallowing of air or water following molting raises the blood pressure and thus makes feasible the expansion of the wings (Shafer, *loc. cit.*). Locomotor activity can increase the blood pressure in the ventral sinus of crabs to an extent of 10 mm. of water (Dubuisson, '28). The blood in the pericardial sinus is always under positive pressure and puncturing this region sometimes results in death due to loss of blood (*cf.* Herrick, '09, for the lobster). Plateau (1880) inserted a glass tube vertically through the carapace of decapod Crustacea into the pericardial sinus without allowing the escape of a single drop of blood. The column of blood in the tube immediately rose to a height of 16 mm. Once the maximum height in the tube was attained it remained invariable except for certain regions in the pericardial sinus where it alternately rose and fell through an amplitude of 1 mm. synchronously with the heart beat. In the spider-crab, *Maia* (Dubuisson, *loc. cit.*), the pericardial blood pressure fluctuates between 21 and 25 mm. of water. These values are very much lower than those in the arteries of vertebrates.

In limbs supplied with arteries, such as in *Limulus*, the blood is under a positive pressure in the arteries as shown by profuse bleeding upon cutting. The blood pressure in the limbs of certain Crustacea (Picken, '36) is 30–20 cm. of water. As it leaves the arteries, the blood is aspirated from the limbs during diastole.

The blood, in limbs provided with arteries is, hence, under both positive and negative pressure. The aspirating action of the heart during diastole is the major factor in producing circulation especially in forms which do not have a well developed arterial system, and these are the majority. This will become evident under the next topic. The arterial pressure of the lobster (v. Brücke & Satake, '12), measured in the aorta in the region of the third or fourth abdominal segments, attains a maximal, or systolic, value of 170 mm. of water; and a minimum, or diastolic value, of 147 mm. of water. In the crab, *Maia* (Dubuisson, *loc. cit.*), this pressure fluctuates around 55 mm. of water and, of course, diminishes with distance from the heart. It is, however, incorrect to suppose with Dubuisson that this pressure remains positive until the blood returns to the pericardial sinus if by "positive" is implied a flow which is the result of propulsion instead of aspiration.

Because arthropods have an open circulation Wigglesworth ('34) has pointed out that their blood pressure is capable of performing important mechanical functions such as hatching, molting, and wing expansion. "The coiled proboscis of Lepidoptera is extended by means of blood pressure created in the stipes of each maxilla" (*cf.* Snodgrass, '35; Schmitt, '38). That the expansion of the wings soon after eclosion is produced by a localised rise in blood pressure was first recognized by Swammerdamm (1669, pt. I, p. 119) regardless of his explanation for the rise in pressure: ". . . these wings are so swiftly expanded, and yet have neither muscles or joints in them, but only artificially plaited or folded. . . . This difficulty surely is worthy to be solved. . . . I think the water, which is warmer on the surface than in the bottom of the river, flowing all over and penetrating into the wings, in order to promote this needful expansion, may be impelled with greater force, in the same manner as we see the blood is, by the help of hot water, drawn more plentifully into the feet, and those parts are more distended when any one is blooded in the foot. . . . Wherefore we likewise observe that in the wings of insects, if wounded at that time, there follows a mortal hæmorrhage, or if the creature survives, the wings are never afterwards displayed." Swammerdamm, in common with

other biologists of his time, did not recognize the haemolymph of insects as blood and thought it to be water.

2. *Circulation*.—a. *Pantopoda*. Although these animals do have a heart, both Carpenter (1854) and Thompson ('09) observed that, especially in species with a small body and exaggerated legs, movement of the blood is produced more by action of the limbs and contractions of the intestinal cæca, which extend into all the locomotor appendages, than by impulses generated by the heart. In fact, Carpenter believed that they possess no specific circulatory organs.

b. *Tardigrada*. Since these minute animals have no circulatory system, movements of the viscera and integument must be adequate in producing blood circulation.

c. *Scorpionidea*. Blood is aspirated into the ventral sinus as a result of the contraction of the muscles attached to the ventral diaphragm. When these muscles relax the ventral diaphragm collapses and blood is thus forced into the lung—"books" whence it is aspirated into the heart as a result of the expansion of the heart muscle. The heart then contracts and propels the blood into the arteries (Potts, '32). Judging from anatomical details, the circulation of the blood in spiders (Clarapède, 1863; Causard, 1892; Wagner, 1893; Willem, '17), *Limulus*, and scorpions is similar.

d. *Crustacea*. Like the *Tardigrada*, *Crustacea* without a heart must depend on movements of the viscera and integument for blood circulation. Amphipod, stomatopod, and decapod *Crustacea* generally have a well developed circulatory system.

Prior to the work of Audouin & Edwards, Latreille (1831), Desmarests (1825), and, in a later work, even Cuvier (1817) succumbed to the notion that the blood enters the gills directly from the heart. This is apparently a relic from Willis' (1674) *De Anima Brutorum* in which it is stated that, during diastole, the heart receives blood from the gills and the "vena cava" (*i.e.*, a mixture of aerated and unaerated blood) and discharges such, during contraction, to the gills and the anterior region of the body. It is of historical interest that Willis drew his conclusion after injecting "a black fluid" into the heart of lobsters.

The most comprehensive work on the circulation of the blood in the *Crustacea* is that of Delage (1881, 1883). In the isopods

the blood is drawn into the ostia of the thoracic sinuses (Fig. 2, *os*) from the body lacunæ, is carried to the abdominal sinus and then, through the afferent vessels (Figs. 2 and 3, *a*), to the gills and aërated (Fig. 3, *gi*). It is then aspirated into the pericardial sinus (Figs. 2 and 3, *p*) and thence into the heart, *h*. All this blood flow is the result of aspiration generated by the heart muscle during diastole. The two walls of the gills are, in many places, confluent (Fig. 3), thus check the rate of blood flow through such, and hence offer a greater length of time for gaseous exchange. The telson of isopods acts as a gill in the same manner. In the læmodipods and amphipods the afferent vessels to the limbs of the thorax and abdomen all come from the sinus system and not, as they do in isopods, from the arterial system. The end result in both cases is, however, quite evidently the same as far as circulation is concerned. In the Anisopoda the carapace folds are transformed into gills, and, as in the gills of other forms, constrictions are formed by the confluent walls of the carapace. During the zœa stage of macrurous decapods there is a similar carapace-branchial system prior to the appearance of the gills.

The pericardial septum of the amphipod, *Phronima sedentaria* (von Haffner, '33), passes into the thoracic legs (Fig. 5, *p*) and thus allows the existence of afferent and efferent blood streams. During systole (Fig. 5A) the heart propels the blood into the head and abdomen. During diastole (Fig. 5B) blood is forced through the limbs by the aspirant action of the heart and pericardial sinus. A similar condition holds for the amphipod *Gammarus pulex* (Klövekorn, '34).

In the decapods, as exemplified by the lobster or crayfish (Fig. 6), blood is propelled into the ambulatory appendages through the limb arteries, *la*, during systole (circulation by propulsion is shown by broken arrows). During diastole blood is drawn from the gills, *gi*, by suction (circulation by suction is shown by continuous arrows) into the pericardial sinus and heart.

How does the blood circulate through the arborous gills of decapods? We have already noted that each gill stem is fully separated into two channels by the pericardial septum (Figs. 6 and 7, *p*): an afferent channel, *a*, and an efferent channel, *e*.

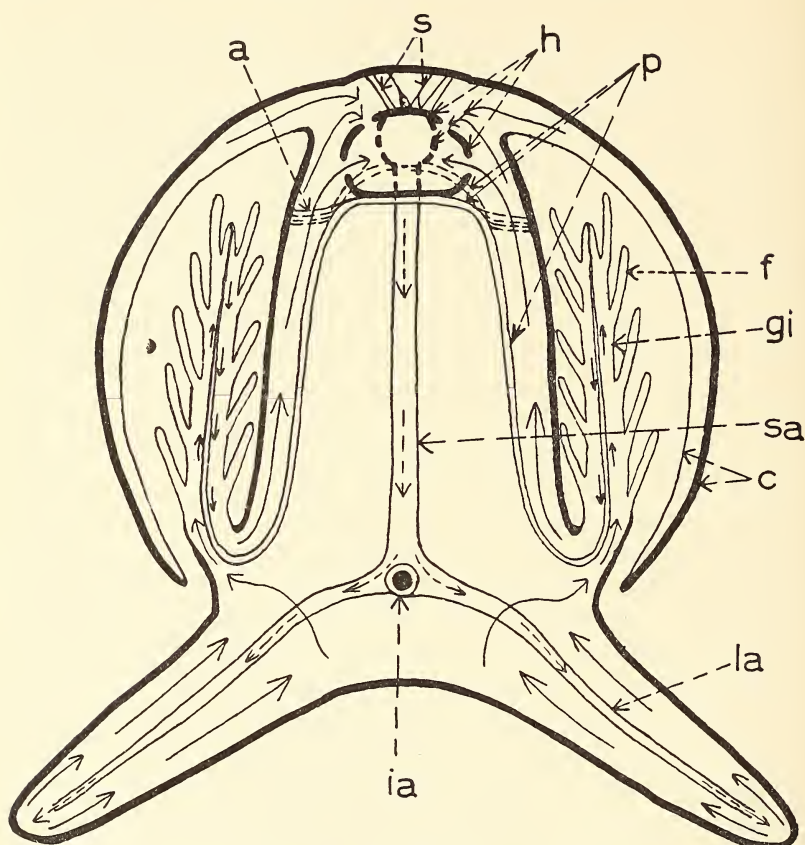


FIG. 6. Transverse section through the thorax of a crayfish. *a*, alary muscle; *c*, fold of carapace; *f*, gill filament; *gi*, gill stem; *h*, heart (small round interior one in systole; the large outer one in diastole); *ia*, inferior artery; *la*, limb artery; *p*, pericardial septum or dorsal diaphragm (position during systole shown by broken line); *s*, suspensory ligaments; *sa*, sternal artery.

Each gill filament, *f*, is also longitudinally divided into an afferent and an efferent channel (Fig. 7). There are many circular vessels in the walls of the gill stem some of which, *c*, open into the efferent channel of the gill stem and others into the afferent channel of the gill stem. The afferent channel in each gill filament communicates with an afferent circular vessel while the efferent channel of the gill filament communicates with an

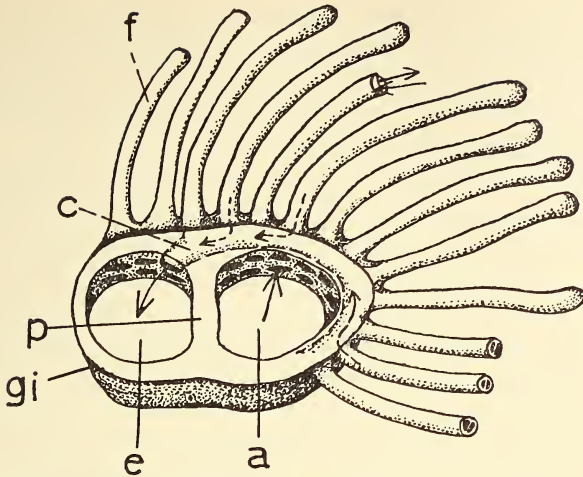


FIG. 7. Diagram of a transverse section through the gill of a lobster showing the course of the circulating blood (arrows). *a*, afferent channel of gill stem; *e*, efferent channel of gill stem; *c*, circular vessel in which efferent channels of the gill filaments open; *f*, gill filament; *gi*, gill stem; *p*, extension of the dorsal diaphragm. Each filament communicates with the afferent channel of the gill stem on the one hand and with the efferent channel of the gill stem on the other. (After Herrick.)

efferent circular vessel. Blood which circulates through the gill stem must, therefore, imperatively pass through the gill filaments before reaching the heart.

In the daphnid, *Leptodora kindtii* (Gerschler, '10), there is a pulsatile vessel in the basal segment of each first leg and attached to the integument by ligaments. An innervated muscle passes from the integument to the wall of the vessel and causes its expansion. *The fact that the walls of the vessel are not muscular is proof that the main action of the vessel is aspiratory.*

e. Hexapoda. In the honeybee (Snodgrass, '25) blood from the thorax passes through the narrow abdominal peduncle and enters beneath the ventral diaphragm. The backward pulsations of the ventral diaphragm cause some of the blood to flow posteriorly. At the same time, the aspirating action of the heart during diastole causes the blood to enter the visceral sinus by way of the lateral intersegmental openings of the ventral diaphragm.

The blood in the visceral sinus receives food material from the intestine and is drawn into the pericardial sinus and then into the lumen of the heart through the ostia of the latter. During systole the blood in the heart is propelled anteriorly and enters the hæmocœle beneath the brain.

The circulation of the blood in the posterior region of the trunk and limbs of chironomid larvæ (Fig. 4) is very similar to what occurs in the regions of the gills and appendages of Crustacea in which the pericardial septa enter the gills or limbs. Afferent and efferent channels in the legs and antennæ have also been noted by Carus (1830) in beetles, by Moseley (1871) in cockroaches and by Leontowitsch ('11) in *Ranatra*. The latter was an adherent of the closed circulation theory and hence believed that the ascending and descending currents occur through definite blood vessels. Meyer ('31) has made the most extensive study of the afferent and efferent channels in the limbs of insects (various species of larval ephemerids). He noted that the longitudinal septum contains nuclei and divides a limb completely, being attached to the inner ends of the hypodermal cells. The septum is not a prolongation of the pericardial septum into the legs since it ends proximally at the coxa. Tracheæ and muscles, however, ensure that the blood from the efferent channel (in the outer longitudinal half of a limb) enters the pericardial sinus.

Circulation in the limbs and wing veins may also be produced by accessory hearts whose action is chiefly aspiratory. Carus (1830) was the first to describe the circulation in the wings and noted that, in beetles, the blood always flowed out in the anterior margin of the wing and back in the posterior margin. Moseley (1871) made similar observations on the cockroach, *Blatta*, and beetles and pointed out that the blood vessels of the wings cannot be looked upon merely as tracheal sheathes since the tracheæ are very small in comparison and do not enter the transverse connecting branches. He suggested that the wings probably act as lungs and that the absence of these "aërating" organs in the female cockroaches is compensated for by the much larger size of the salivary glands of the latter—which were also supposed to behave as lungs (see also Mr. A. Hollis, to whom Moseley refers).

Yeager & Hendrickson ('34) confirmed, in the adult cockroach, *Periplaneta americana*, the observations of Carus and Moseley. In the larval wing pads, however, the former observed that the "blood flows centrifugally in all the main veins, including the vannals; these streams turn medially and become centripetal with respect to the posterior border of the tergum. . . ." Moseley had noted that, under conditions of exhaustion, the current in the posterior margin of the hind wing of the adult cockroach may be reversed—the circulation thus evidently reverting to the immature condition.

In the cockroach (Yeager & Hendrickson, *loc. cit.*) "part, at least, of the blood from the elytra and wings passes into the heart cavity through the mesotergal and metatergal pulsatile organs, respectively." The same may be said for ants (Janet, '06), honeybees (Freudenstein, '28), dragonflies, wasps, moths, grasshoppers and beetles (Brocher, '16, '31), and various mayfly adults (Bervoet, '13; Meyer, '31). This is effected by the aspirating action of the pulsatile organs (Meyer). The average velocity in the subcostal cell of a cockroach elytron is 34.3 mm./min. (Tauber & Snipes, '36). In *Dytiscus* and *Aeschna* (Brocher) the lumina of the pulsatile ampullæ communicate with the lumen of the aorta; in *Sphinx* (Brocher) and in *Apis* (Freudenstein) there is no communication. In the two-winged insects, or *Diptera*, and in a certain ephemerid, *Cloëon*, having only a single pair of wings (mesothoracic) only the mesothoracic organ exists (Zimmermann, 1880; Popovici-Bazosanu, '05; Drenkelfort, '10; Meyer, '30). Thompson ('38) has, however, noted a pair of pulsatile organs in the mesothorax of the domestic fly and also one in each wing. There is no direct connection between these vessels and the aorta. Those in the thorax begin to function in the pupal stage while those in the wings act only after the out-folding of the wings.

Janet and Freudenstein believed the tergal organs to be muscular plates which are attached to the integument laterally. On the other hand, Zimmermann, Brocher, and Meyer (*loc. cit.*) have described such as sac-like ampullæ. The contractions of these organs may be regular (Meyer) or irregular (Zimmermann) and are not synchronous with or dependent on the heart beat (Brocher

'16, Freudenstein, and others). Most of the ampullæ have ostia, but those of the ephemerid, *Heptagenia* (Meyer), appear to be exceptional since no blood flow into such could be observed. Circulation of blood in the wings is necessary for the deposition of pigment in such (Tenenbaum, '34).

In the adult dragonfly (Whedon, '38) there is an aortic diverticulum to the lumen of the axillary cord of each wing. Blood, which is propelled to the anterior (costal) "veins" of the wings by the contraction of the heart and leaves the aorta, is drawn through the wing "veins" into the axillary cord.

Pulsatile organs have been noted in the legs of various species of aquatic Hemiptera and other insects (Behn, 1835; Locy, 1884; Leontowitsch, '11; Crozier & Stier, '27b; Thompson, '38; and others), and have been found to occur in between the bases of the antennæ of ants, bees, and cockroaches (Pawlowa, 1895; Janet, '11; Brocher, '16, '22; Freudenstein, '28). Since they occur in the path of the efferent blood stream (Leontowitsch) it is clear that their action is chiefly aspiratory. The organs are attached to the integument by passive ligaments and, unlike the organs in the fore-legs of a daphnid (see above), they apparently have no extrinsic muscles. Blood currents in the legs of the Hemiptera are dependent on the organ as shown by their cessation when the organ stops. Locy observed that the rate is irregular and is always faster than the heart rate in a given individual. Not only is the rhythm of the vessels independent of the heart but also the rhythm of one vessel is independent of that of the contralateral half in the intact animal (Locy, 1884; Crozier & Stier, '27b). In contrast to Locy, Crozier & Stier found that the rate of pulsation in any one leg of *Notonecta* is remarkably uniform at a given temperature although individual variation was considerable.

3. *Bodily motions associated with the heart beat.* In spiders (Willem & Bastert, '17) the abdomen, the appendages (when free), and the flexible regions of the integument respond to the small changes in blood pressure by undergoing pulsations of small amplitude synchronously with the heart beat. The lung-"books" perform like a harmonica. In *Limulus* (Tait & Berrill, '36), too, the rhythmic volume change of the gill-"leaves" occurs

in precise *tempo* with the heart beat and "derives presumably from changes in blood pressure"; and the dilation of the heart is coincident with the elevation of the gill-"plates" (Edwards, 1872). The to-and-fro movements of the gills, however, *i.e.*, the respiratory movements proper, are not dependent on changes in blood pressure partly because they will continue even after the heart and blood are removed (Hyde, '06). In the larvæ of certain mayflies (Meyer, '31) the volume of the legs increases during systole and decreases during diastole.

C. THE HEART BEAT

1. *Role of the alary muscles and suspensory ligaments.* A cardiac muscle must be stretched beyond a certain minimum if it is to contract vigorously. The alary muscles which are attached to the dorsal surface of the heart and laterally to the integument, are necessary if the heart is to beat with its normal amplitude although their section does not necessarily result in a cessation of the rhythmic beat (Plateau, 1880; Snodgrass, '35; Dubuissou, '29, '30; Izquierdo, '31; Maluf, '35). Swammerdam (see above) believed that they expand and contract the heart.

Since the heart is attached dorsally to the integument by means of the suspensory ligaments, the alary muscles must, during diastole, stretch the heart muscle and thus increase the energy of contraction (Starling's "law of the heart," '20, p. 1003).

Carlson ('04-'05b, '06, '07a) had observed that, when the heart of *Limulus* was quiescent due to exhaustion and when the arteries were ligated and the heart was perfused under slight pressure, a series of beats was produced. These effects, however, resulted only when the cardiac ganglion was intact. Increasing the pressure up to a certain unspecified limit augmented the amplitude, tonus, and rate. The same effects were produced by stretching the suspensory ligaments or by attaching opposite hooks to the middle region of the heart. These results were confirmed by Dubuissou ('30, '30-'31a) and Heinbecker ('33) with the exception that they could obtain the same effects on the deganglionated heart. It is possible that Carlson had used hearts of unhealthy animals. The effect of loss of blood and, hence, of internal cardiac pressure on the de-

crease of the heart rate of Crustacea was nevertheless well known to Carlson ('06).

A certain degree of stretch is necessary for the automaticity and rhythm of the hearts of all invertebrates (Hoshino, '25; Dubuisson, '29, '30; Heinbecker, '33) and although the free excised hearts of some arthropods may beat spontaneously for some time when placed in a perfusion medium (Hunt, Bookman, & Tierney, 1879; Plateau, 1879; Cosmovici, '25; Rijlant, '32; Carlson, etc.) they come to rest prematurely, *e.g.*, the lobster heart (H., B., & T., *loc. cit.*). In the dragonfly, *Agrion*, and the beetle, *Hydrophilus* (Dubuisson, '30), section of the alary muscles causes an immediate stoppage of the heart beat. This is, however, not generally true (*cf.* foregoing authors) provided, of course, that the heart is placed in a balanced perfusion medium. When the heart of the larva of the dragonfly, *Anax junius*, or of the bug, *Belostoma flumineum* (Maluf, '35), is carefully removed from the body wall it generally ceases to beat instantly although there may be a few quivers when it is in a state of collapse. The suspensory ligaments are thus necessary for heart function in these forms—that is, provided the perfusion pressure is not artificially raised. The term “isolated heart” in the paper of Yeager & Hager ('34) must not be taken in its strict sense since the dorsal integument, alary muscles, and suspensory ligaments were kept intact. The same applies to the work of Brocher ('17), Lévy ('28), and Koidsumi ('31) on insect hearts. In fact, as far as I know, a contracting isolated insect heart has never been maintained over any protracted period. The reason for this is probably merely due to difficulties in maintaining a perfusion pressure in such small hearts.

Certain authors, such as Popovici-Baznoșanu ('05) and Dezső (1878), believe that the pericardium is passive in its effect on the increase in heart volume during diastole. In fact, Dezső contradicted Dogiel (1877) by stating that the pericardium of the crayfish is not muscled. On the other hand, Dubuisson ('29) seems to have shown that the sudden unusual heart stops which occur, every now and again, during the diastolic phase of certain midge larvæ (*Chironomus dorsalis* and *C. plumosus*) are due to a relaxation of the alary muscles and thus to a release of the heart muscle from a point of critical stretch. He logically concluded that

arthropods which do not show such pauses, such as adults of the above, always have their alary muscles in a state of quasi-contraction. He recognized a point of critical stretch at which the effects on the energy of contraction were all-or-nothing. It is disconcerting to know, however, that the heart of the *Corethra* larva (Tzonis, '36) pauses in systole.

2. *Innervation*.—a. *Onychophora* and “*Myriapoda*” have a ganglionated median dorsal nerve cord (Gaffron, 1885; Lang, 1891) similar to that of *Limulus* and many Crustacea.

b. *Xiphosura*. The gross structure of the cardiac nervous system of *Limulus* (Fig. 8) has been studied by Carlson ('04-'08) and, in detail, by Edwards (1872) and, as to its minute structure,

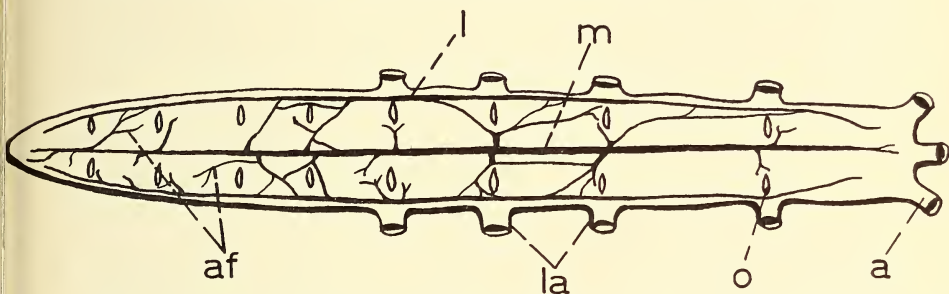


FIG. 8. Dorsal aspect of the heart of *Limulus* with the anterior end to the right. *af*, afferent nerve fibers; *a*, artery; *l*, lateral cardiac nerve; *m*, median cardiac nerve cord; *o*, ostium. (After Carlson.)

by Patten ('12) and Heinbecker ('33). The term “ventricle” in Heinbecker’s paper really implies the heart. The intrinsic innervation consists mainly of a ganglionated median dorsal nerve cord (Fig. 8, *m*), or cardiac ganglion, which is connected with the stomatogastric nervous system by a pair of branches (Edwards, 1872). There are more ganglion cells in the middle region of the cardiac ganglion than in the anterior or posterior regions. The cells are of three kinds (Patten): 1. Small multipolar cells forming a thick irregular covering around the ganglion. In the first three or four segments these cells are few. 2. Giant bipolar cells, not present in the first three or the last segments; give off large branching collaterals. 3. Small bipolar cells; not numerous; found in the first three or four segments. All the ganglion cells increase greatly in number with age, while those of the Crustacea

and insects, on the other hand, remain approximately constant. No ganglion cells exist in the heart of *Limulus* outside of the median cord (Carlson, '08; Patten, '12), although the radiating branches which connect the cardiac ganglion to the lateral nerves (Fig. 8, *l*) contain a few ganglion cells at their roots (Patten, Heinbecker). Afferent nerve fibers, *af*, pass to the cardiac ganglion from every region of the heart.

The cardio-inhibitor nerves arise from the brain (Carlson, '05) and decrease the rate and amplitude but not the tonus of the beats (see also Hoffmann, '11a). For the following reasons, Carlson suggested that the action of the inhibitor nerves is not exerted directly on the heart muscle but rather on the cardiac ganglion:

1. "The inhibitor nerves enter, not the heart muscle, but the nerve cord on the dorsal side of the heart in the region of the second and third pairs of ostia.
2. "The response of the heart to direct stimulation when quiescent in prolonged diastole, due to strong stimulation of the inhibitor nerves, is similar to the response of the heart to the same stimulus after extirpation of the cardiac nerve cord. Complete inhibition thus simply means the throwing out of function of the median cardiac nerve cord.
3. "Atropine, nicotine, and curare . . . paralyse the inhibitor mechanism of *Limulus* only when they come in contact with the ganglion on the dorsal side of the heart.
4. "If the inhibitor nerves pass from the cardiac nerve cord to end in the heart muscle it ought to be possible to produce inhibition by stimulation of these fibers on their course from the nerve cord to the muscle. This is never possible. Contraction only is produced then."

Heinbecker (*loc. cit.*) found that when the inhibitor ("vagus") nerves are cut the heart beats more rapidly. "The chronotropic responses are naturally inferred to act directly on the large ganglion or pacemaker cells. But, inasmuch as the small ganglion cells have been shown to have an autochthonous rhythm independently of the large ganglion cells it follows that, in order that the heart be stopped by intrinsic fibers these must also act on the small ganglion cells." Stimulation of the inhibitor nerves causes a decrease in the production of CO_2 by the cardiac ganglion (Garrey, '20b). Inhibitor stimuli applied to the cardiac ganglion (Asher & Garrey, '30) decrease the O_2 consumption rate of the same (Dann & Gardner, '30).

The cardio-augmentor nerves arise from the abdominal ganglia and reach the heart together with the inhibitor nerves (Carlson, '05). The fact that the farther posteriorly the location of the stimulus the fewer the augmentor nerves stimulated indicates that the true origin of the fibers is in the anterior part of the central nervous system.

c. *Scorpionidea*.—Here, too, there is an intrinsic elongated dorso-median cardiac ganglion (Police, '02; McClendon, '12; Rijlant, '33a) which has the same functions as that of *Limulus* (Rijlant, '33a). A branch of the stomatogastric nervous system innervates the heart (Police, '03) and possibly, as in *Limulus*, connects with the cardiac ganglion.

d. *Araneida*. The electrical activity of the heart of spiders (Rijlant, '33) is so similar to that of *Limulus* that it suggests that the heart of spiders has a similar ganglionic system. The heart of a tarantula (Carlson, '05-'06a) receives augmentor nerves from the suboesophageal complex.

e. *Crustacea*. Probably the most systematic studies made on the innervation of the crustacean heart are those of Alexandrovicz ('32, '32a, '34) on isopods, stomatopods, and decapods and of Suzucki ('35) on decapods and isopods. In all cases there is a ganglionated nerve cord running along the dorsal surface of the heart. The cells are always few in number. Thus, the cardiac ganglion of the hermit crab, *Aniculus aniculus* (Suzucki), has but ten large multipolar cells while that of the isopod, *Tylos granulatus* (Suzucki), has but six multipolar cells in a row. There are never any ganglion cells at the ventral surface of the heart (see also Newmywaka, '28). Nerve cells in the walls of the crustacean heart had been described by Berger (1876), Deszö (1878), Yung (1878), Dogiel (1877, 1894), Plateau (1880), and Nusbaum (1899); but Claus (1878) and Pogorschewa (1890) were apparently the first to recognize that these cells are generally connected to form a chain. In the prawn, *Palaemon* (Nusbaum, 1899), the ganglionic cells are not connected into a chain but rather form a nerve net. In the crayfish, *Astacus fluviatilis* (Newmywaka, *loc. cit.*) there is no median cardiac ganglion but there is a short transverse ganglionated chain which branches out, the branches, too, containing ganglion cells. There are no ganglion cells in the

arteries of decapod and stomatopod Crustacea according to Alexandrowicz ('12-'13) but Nusbaum (*loc. cit.*) states that he found ganglion cells in the subneural artery of *Palaemon*.

As to the extrinsic innervation, the compound thoracic ganglion, or complex, of decapods and stomatopods gives rise to both the augmentor and inhibitor nerves. The inhibitor nerve of *Palinurus* (Carlson, '04-'05, '05-'06a) arises near the origin of the nerve to the third maxilliped of its side (see also Dogiel, 1877). The cardio-augmentor nerve of the same animal arises near the nerve to the first ambulatory appendage of its side. A similar condition holds for the stomatopods and other decapods judging from the anatomical work of Alexandrowicz ('32, '32a, '34), the physiological studies of Yung (1878, 1879), and the anatomico-physiological papers of Jolyet & Viallanes (1892), Conant & Clarke (1896), and Bottazzi ('01). Stimulation of an augmentor nerve causes, as in *Limulus*, a stoppage of the heart beat in diastole; of an augmentor nerve, produces an increase in the heart rate and amplitude of *Palinurus* (Carlson, '05-'06a) and in the heart rate and tonus, but not amplitude, of *Maia* (Bottazzi, *loc. cit.*). In the crab, *Callinectes hastatus* (Conant & Clarke), there is, however, no evidence of tonic activity from either type of nerve. Thus, the thoracic ganglion complex can be removed without producing any apparent effect on the heart rate.

Lemoine (1868) once figured and described a median cardiac nerve issuing from the stomatogastric ganglion of the crayfish. Yung (1878, 1879) and Plateau (1880) stated that the existence of the nerve is incontestible; that it is an augmentor; and that cutting it produces a slowing of the heart rate. They were backed up by Mocquart (1883) in the shrimp and by Keim ('15) in the crayfish. On the other hand, Jolyet & Viallanes, Retzius (1890), Conant & Clarke, and Carlson ('04-'05, '08b) searched vainly for Lemoine's unpaired "nerve cardiaque" since stimulation and cutting in the region in which it was supposed to exist produced no apparent effects on the heart.

Other nerves from the thoracic complex innervate the valves and dorsal diaphragm (Alexandrowicz, '32, '32a, '34). The nerve fibers to the valves probably maintain the muscles of the latter in a state of contraction during the diastolic phase.

f. *Hexapoda*. The only detailed studies on the innervation of the heart of insects are those of Zawarzin ('11) on the larva of a dragonfly, *Aeschna*; of Alexandrowicz ('26) on the cockroach, *Periplaneta*; and of Opoczyńska-Sembratova ('36) on the phasmid, *Carausius morosus*. In these insects, as in *Limulus* and many Crustacea, there are no ganglion cells scattered about the walls of the heart. On either side of the heart of *Aeschna* is a longitudinal nerve which Zawarzin considered to be probably derived from the stomatogastric ganglion. Lyonnet (1760), in an exquisite anatomical work, noted that each side of the heart of a caterpillar receives a nerve from the homolateral stomatogastric ganglion. Each cardiac nerve of *Anax* (Maluf, '35) and *Aeschna* is but an elongated axon with no ganglion cells in the region of the heart but with neurilemma nuclei sparsely scattered. The heart also receives motor branches from the abdominal ganglia (cf. also Lyonnet, 1760). The cockroach and phasmid heart is provided with lateral nerves consisting chiefly of processes from ganglionic cells scattered alongside the nerve. Those of the cockroach, at least, are connected anteriorly with the stomatogastric ganglia.

Mechanical stimulation of the brain of a grasshopper, *Dictyophorus reticulatus* (Carlson, '05-'06a), frequently caused a cessation of the heart beat in a state of diastole. On the other hand, electrical stimulation of the brain of this grasshopper and of a moth, *Telea polyphemus*, often produced an augmentation in the rate and amplitude of the heart beat. The same augmentor effects occurred after severing all nervous connections of the brain except those connecting it with the thoracic and abdominal ganglia. The rate and amplitude of the heart beat were similarly augmented on stimulating the thoracic and abdominal ganglia. Electrical stimulation of the brain of a stag-beetle larva (Lasch, '12-'13), produced a retardation of the heart beat. It is evident that the inhibitor nerves are connected with the brain by way of the stomatogastric nervous system and are probably the lateral intrinsic nerves of the heart. The augmentor nerves are extrinsic nerves and issue from the abdominal ganglia.

Removal of the head has no effect on the periodic reversal of the heart beat of insects (Gerould, '33).

3. *Origin of the heart beat*.—a. *The myogenic basis of the beat*. The embryonic heart of *Limulus* (Carlson & Meek, '08) begins to

beat before any fundament of the cardiac nervous system has appeared. The heart of the lobster (Herrick, '09) begins to beat when the nervous system is only roughly blocked out and long before any nerves are developed. The heart of the larva of the dragonfly, *Anax junius* (Maluf, '35), will continue to beat rhythmically without any connections with ganglion cells. The excised heart of *Bombyx mori* (Kuwana, '32) will continue to beat even though the heart has no intrinsic ganglion cells. The same is probably true of *Corethra* larvae (Walling, '08) notwithstanding Dogiel's (1877a) assertion of "birnförmige Körper" in the heart of the latter. The heart beat of vertebrate embryos has been proved beyond doubt to be myogenic (His, 1893; Hooker, '11; Burrows, '12). Meager indirect evidence indicates that the heart of the crayfish (Plateau, 1879) is myogenic. About 0.5 mg. of curare were injected into the h  molymp. At the end of an hour the animal appeared dead and was irresponsive to stimuli but the heart continued to beat for several hours. Among vertebrates, the classic experiments of Claude Bernard have shown that curare prevents transmission from nerve to muscle. One cannot say, however, whether the drug penetrated the neurilemma sheath, especially in view of other negative results on the effects of curare on arthropod hearts (p. 269).

b. *The neurogenic basis of the beat.* Owing to the presence of ganglion cells scattered about the heart wall of vertebrates after a certain stage of embryonic development, and owing to the fact that the vertebrate heart will continue to beat even after being detached from the rest of the nervous system, it has never been possible to determine whether the pulsations of the vertebrate heart are due to possible rhythmic impulses discharged from the intrinsic ganglion cells. Taking advantage of the condition in *Limulus*, Carlson ('04-'05a, '05-'06, '06) found that removal of the cardiac ganglion produces immediate and perpetual cessation of the beat (see also Garrey, '30) and that co  rdination is entirely dependent upon the integrity of the cardiac ganglion and lateral cardiac nerves. Carlson's classical experiments on co  rdination have been confirmed on an isopod (Alexandrowicz, '32b), on scorpions (Rijlant, '33a), and on *Limulus* (Nukada, '18; Dubuisson, '30-31a; Heinbecker, '33, '36). But Hoshino ('25), Dubuisson ('29,

'30), and Heinbecker (*loc. cit.*) showed that the completely deganglionated heart of *Limulus* will continue to beat, after a temporary arrest, provided it is adequately distended. In the deganglionated heart the propagation of the contraction wave is slow, and not practically simultaneous throughout the length of the heart, as it is when the intrinsic nervous system is intact. These investigators thus concluded that the heart of even the adult *Limulus* is capable of myogenic automatism and Dubuisson ('30-'31, '31) considered that, even in the normal heart, the intrinsic nervous system is of importance solely in synchronizing the beat throughout the length of the heart. Heinbecker ('31, '33, '36) and Rijlant ('31c, d) showed that ganglion cell activity precedes muscular activity by 30-80c. Rijlant ('31) presented more evidence for the neurogenic theory as applied to the normal *Limulus* heart by finding that the spontaneous discharges from the isolated cardiac ganglion correspond with the waves of the muscular action current. There were short waves superimposed on long waves (see also Hoffmann, '11, for the whole heart of decapods and *Limulus*), the superimposed waves being considered to represent associations.

Electrical stimulation of one of the lateral cardiac nerves of *Limulus* (Garrey, '33) caused the beats of the homolateral side to be superposed on a raised tetanic base while those on the opposite side of the heart were altered to a far lesser extent. This was held to show that the stimulated nerve does not innervate all of the contractile elements of the same side as would be the case if muscular conduction were effective. "The proof is conclusive that there is no muscular conduction in the normal adult *Limulus* heart, and consequently there can be no myogenic rhythm." The results of Dubuisson and of Heinbecker show that such an attitude is extreme and the statement "to a far lesser extent" implies only a quantitative difference between the rate of transmission in nerve and muscle. The heart muscle of arthropods is essentially a syncytium (see, for instance, Weismann, 1874; Gerschler, '10; Zawarzin, '11; Baumann, '21) and there is, hence, no apparent reason why muscular conduction cannot occur. From what has been said, there seems to be little ground for doubt, nevertheless, that the beat of the adult *Limulus* innervated heart is neurogenic.

The variations in temperature, affecting the ganglion cells alone, yield temperature coefficients which are almost identical with those for the whole heart (Garrey, '20, '20a).

The data of Magnus ('02) and Sollmann ('05-'06) indicate that the heart beat of an adult vertebrate is neurogenic, although Magnus failed to realize the implications of his results. "If the mammalian heart rhythm is myogenic, it is difficult to explain why pressure in the ventricular cavities is not just as efficient or even more efficient a stimulus to rhythm than the pressure in the coronary vessels. On the neurogenic theory afferent fibers or nerve endings in the walls of the coronary vessels are stimulated by the distension of the walls . . ." (Carlson, '06).

4. *Pacemakers and the sequence of the heart beat.* In 1669 Malpighi recorded a periodic reversal in the direction of the heart conduction of the silkworm (*Bombyx*) pupæ and adults. Cornalia (1856) confirmed, on the pupa, Malpighi's observations. De Réaumur (1734) stated that in the *Bombyx* pupa and adult the pulsations are backward and, in the larva, forward. Bataillon (1893) confirmed this and noted that at the onset of metamorphosis, the time interval occupied by the backward pulsations gradually becomes predominant until, in the pupa, forward pulsations cease to occur. The truth, as Fischer ('18), Gerould ('29, '31), and Tirelli ('36) have observed, lies in a fusion of the findings of all three above investigators. Thus, while predominant, the backward pulsation is not the sole type of sequence in the pupa and the forward pulsation not the sole type in the adult. Reversals occur in the pupæ and adults of all Lepidoptera examined, in certain flies and beetles, and in hymenopterous adults. The alternations are fairly regular (Gerould, *loc. cit.* and '33). In lepidopterous larvæ the pulsations were always forward. No reversals have been noted in neuropterous odonate, or *Belostoma* adults (Gerould, '33; Maluf, '35), nor in dragonfly larvæ (Maluf, *loc. cit.*). Reversals occur in certain Crustacea (Leydig, 1889) and in unhealthy *Lumulus* adults (Pond, '20-'21). Jahn, Crescitelli, & Taylor ('36) found, in the grasshopper, that potential variation as well as direction of waves of contraction show reversals.

While in the healthy *Limulus* the pacemaker does not shift from end to end of the heart it varies in its location from time to time

(Garrey, '30; Dubuisson, '30-'31, '30-'31a) its only approximation to constancy being that the anterior segments normally beat later than the middle segments (Nukada, '18; Edwards, '20; Pond, '20-'21). The greater automatism of the fifth, sixth, and seventh segments is due to the fact that these segments have the greatest number of ganglion cells (Carlson, '04-'05b). The time sequence cannot be detected by the naked eye but when the heart is exhausted it is noticeable that the beat starts somewhere between the middle and posterior end (Carlson, '04-'05a). This is also generally true of the higher Crustacea (Plateau, 1880).

Heat, applied to local spots of the cardiac ganglion of *Limulus* (Garrey, '30), transfers the pacemaker to such spots and accelerates the heart beat. On the other hand, when localized cold is applied, "as long as any part of the ganglion remains at the original temperature . . . the original temperature will determine the rate of the whole heart. Even if three-fourths of the ganglion is thus cooled there is no change in rate."

Considerable light has been thrown, on certain conditions producing reversals, by Yokoyama ('27) and Gerould ('31) who found that premature reversal of the beat in *Bombyx* can be induced in the larva about to spin by sealing the posterior-most pair of spiracles. Injection of lactic acid in the posterior region of the abdomen or narcotizing this region with ether, alcohol, or xylol acted similarly. The fact, that when the metabolic rate of the posterior end is lowered the next predominant region becomes the anterior end, indicates that the direction of the heart beat depends upon a U-shaped excitability gradient in the heart, generally with the highest point at the posterior end and the next highest at the anterior end. When the high point, or pace-maker, at one end is demolished the other acquires the lead. In this connection it is noteworthy that Gerould ('33) found that the frequency of the beats in a given direction gradually decreases until a reversal occurs.

The pulsatile organs in the legs of Hemiptera (Locy, 1884) undergo contraction from the distal to the proximal end.

It has been noted above that the rate of propagation of the contraction wave varies with factors such as fatigue and stretch. To such should be added temperature. In the *Limulus* heart, under

ordinary experimental conditions, the rate of propagation has been found to be about 73 cm. per second (Edwards, '20; Pond, '20-'21). Carlson's ('05-'06) data show that the rate of conduction in the cardiac ganglion is of the same magnitude, namely, ca. 41 cm. per second, this being about 9 times less than that in the motor nerves to the limbs. He also produced evidence ('05-'06b) for a direct relation between the rate of conduction in a motor nerve and the rapidity of contraction in the muscle it innervates. But Dubuisson ('30-'31) found that the speed of the contractile wave of the *Limulus* heart, when healthy and adequate distended, is generally over 1,000 cm. per second although quite variable. This is much higher than any of the values given above and requires confirmation. The rate of propagation of the contraction wave of the lobster's heart (Clarke, '27) is 40 cm. per second and, as in *Limulus*, the sequence cannot be detected by the naked eye.

The sequence of the heart beat in insects is much lower than in *Limulus* and the higher Crustacea and is thus easily detected by the unaided eye. The maximal, average, and minimal rates of conduction of the contraction wave in the larva of the stag-beetle, *Lucanus cervus* (Lasch, '12-'13), are 44.3, 27.2, and 19.5 cm. per second; in the heart of the moth larva, *Cossus cossus* (A. Seliškar, unpublished; cf. Clark, '27), the conduction rate is about 2.4 cm. per second at 15° C.

5. *Frequency.* The heart rate varies with numerous factors such as general metabolic rate, fatigue, stretch, and the presence of various agents in the blood. Even under apparently identical conditions the heart rate of different individuals of a given species and age varies considerably (Table I). In a given individual under normal conditions, however, the rate is fairly constant (Pickering, 1894; Robertson, '06; Maluf, '37) although the frequency of the periodic arrests which occur in certain species is very variable. While there is no well defined relationship between the heart rate and the phylogenetic position, it is clear that the rate in Crustacea, Scorpionidæ, and Pycnogonida is considerably higher than among *Limulus* and insects. This is correlated with the fact that only few insects have blood gills, and even when these exist they are of no marked respiratory significance (Fox, '21). Exception should be made of *Chironomus* larvæ, which

have a high heart rate and *the blood of which has a significant respiratory function* (Leitch, '16).

Even before van't Hoff and Arrhenius made their classical quantitative studies on the relationships of the rate of chemical reactions to temperature, Carus (1824) and Newport (1839) found that warmth accelerates the heart rate of crustaceans and insects. In the crustacean, *Ceriodaphnia* (Robertson, '06), between 15° and 31° C., the Q_{10} averages 2.03, varying between 1.14 and 2.66 and falling with rise in temperature. Between 8° and 28° the Q_{10} for crayfish embryos is 2 to 2.6 (Zehnder, '34). In the insects and crayfish studied by Polimanti (Table I) the Q_{10} is never as high and varies between 1.2 and 1.6, falling with rise in temperature. Both the Q_{10} and μ of enzymatic processes *in vitro* decrease regularly with temperature possibly due to a decrease in the viscosity of the substratum (Bělehrádek, '28, '30) although Stiles ('30) has concluded that viscosity plays only a small rôle in determining the rate of biological reactions. For interpretations of Crozier's temperature characteristics for the heart rate of arthropods *cf.* Crozier & Federighi ('25), Fries ('26), Crozier & Stier ('27, '27a), Matsuki ('27), Henderson ('27), Koidsumi ('28, '31), Stier & Wolf ('32), and Barnes ('37).

Moderate temperatures, such as 35° C., are lethal to a number of Crustacea (Robertson, '06; Coker, '34, '34a; Maluf, '37a). The optimum temperature for the rate and amplitude of the *Limulus* heart is 10°–15° C. (Carlson, '05–'06c) and the upper and lower limits for a heart in good condition are –1° and 42° C. When in poor condition the heart muscle may cease to respond at 25°. The cardiac ganglion and the intrinsic motor fibers are more heat-resistant than the heart muscle.

Polimanti ('15a) presented evidence that the heart rate of silkworm larvae decreases with decreasing light wave-length in the visible region. It was not, however, determined whether blinded animals will react likewise or whether the effect is merely one of intensity or of the *quantity of energy absorbed*. The italicized factor has been overlooked in all studies on the photoreception of animals. Ultra-violet rays soon bring the heart of daphnids to a standstill (Tchakhotine, '35).

The substance released by the eye-stalks of many Crustacea and which produces a condensation of the pigment granules in the

TABLE I
A REPRESENTATIVE LIST

Species	Average heart rate per min. at 25° C. ¹	Remarks	Investigators
Xiphosura:			
<i>Limulus</i>	12-28	.....	{ Carlson ('04-'05a) { Dubuissou ('30-'31)
Scorpionideæ	120-225	Greater rate in young of a given species.	Rijlant ('33, '33a)
Acarina	90-300	.....	"
Pycnogonida:			
<i>Polixichilidium</i>	180-370	.....	"
Crustacea:			
<i>Ceriodaphnia</i>	6	.....	Robertson ('06)
<i>Daphnia</i>	312	.....	Pickering (1894)
<i>Daphnia</i>	188-289	.....	Knoll (1893)
<i>Cancer</i>	9-120	.....	Carlson ('06)
<i>Cancer</i>	15-30	When bled.	"
<i>C. pagurus</i>	80.5	.....	Eckhard (1867)
<i>Pagurus longicarpus</i>	167-250	Rate greater in young.	Maluf ('37)
<i>Carcinus maenas</i>	16.8-94.5	.....	Plateau (1880)
<i>Maia squinado</i>	37	.....	Knoll
<i>M. verrucosa</i>	98	.....	Polimanti ('13)
<i>Mysis</i>	380	.....	Knoll
<i>Caprella</i>	180-240	.....	"
<i>Squilla eusebia</i> (larvæ)	216	.....	"
<i>Porcellana</i> (zœa)	255	.....	"
<i>Astacus fluvialtilis</i>	119-153	.....	Plateau
<i>A. fluvialtilis</i>	57	.....	Polimanti
<i>Cambarus virilis</i>	59	.....	Welsh ('37)
<i>C. virilis</i>	82	Injected with eye-stalk.	"
<i>Hippolyte</i>	360	Pale or nocturnal phase.	Keeble & Gamble ('00)
<i>Hippolyte</i>	225	Dark or day phase.	" "
Insects:			
<i>Oryctes nasicornis</i>	18	Exposed heart.	Polimanti
<i>Bombyx mori</i> (larvæ)	54	.....	Polimanti ('15)
<i>Lucanus cervus</i> (larvæ)	24	.....	Lasch ('12-'13)
<i>Chironomus dorsalis</i>	162	.....	Dubuissou ('29)
<i>C. plumosus</i> (larvæ)			

¹ A Q₁₀ of 2 is assumed. "Room" temperature is taken as 20° or 25° C., depending upon the locality or season.

chromatophores also raises the heart frequency (Welsh, '37). In 1900, Keeble & Gamble, too, had noted that the pale phase of a prawn is accompanied by a higher heart rate than the dark phase. They, however, supposed such to be under the entire control of the nervous system.

The heart rate is not necessarily a strict index of the metabolic rate, for, while small hermit crabs (Maluf, '37) have a significantly higher heart rate than the larger individuals (see also Rijlant, '33, '33a for scorpions), their rate of oxygen consumption is not appreciably greater. Furthermore, while the heart rate of Crustacea is generally greater than that of insects (see table I) the metabolic rate of the latter is commonly much higher (*cf.* Parhon, '09). This is an outcome of the fact that the circulation has ceased to be of respiratory importance to most insects.

6. *Refractoriness, tetanus, and automatism.* It is generally known that, because of the presence of a relatively long refractory period (occurring during systole), the fundamental contractions of the vertebrate heart cannot be summated and tetanus cannot be produced. By stimulation at a low frequency, however, summation of the underlying contractions of the vertebrate heart is possible. The tetanus then is not the result of a fusion of the fundamental contractions (which does not occur) but of the tonus contractions with partial or even complete masking of the fundamental contractions (see Ranvier, 1880; Langendorff, 1895; Walther, 1898; Cyon, '00; Danilewsky, '05; especially Porter, '05-'06, and several others).

According to some investigators the heart of all arthropods and of all invertebrates, so far as studied, has no refractory period though there is, during systole, a condition of reduced excitability (Hunt, Bookman, & Tierney, 1897, for the lobster; Carlson, '03, for tunicates, molluscs, and crustaceans; Carlson, '06a, '06b, '07, '08a, for *Limulus*; Hoffmann, '12, for *Maia*). That the heart of invertebrates can, in most cases,² be tetanized was first noted by Eduard and Ernst Weber (1846), the classical "Weber brothers" often mentioned in physiological text-books; and has been confirmed by the above investigators as well as by Brandt (1865), Plateau (1878, 1880), Dogiel (1894), Polimanti ('13), de Boer

² The heart of certain gastropods (Carlson, '03) cannot be tetanized.

('28), and Garrey ('33). Hunt, Bookman, & Tierney pointed out that *the tetanic contraction is due to the summation of single fundamental contractions* and is not a prolonged single contraction.

Recently, de Boer ('28) and Izquierdo ('31), both of which testified to the capacity of the crab's heart to undergo tetanus, found that the heart of *Maia* does undergo total refractoriness of short duration (0.2 sec.) during systole. They claim that Hoffmann's results were obtained on an empty heart and that Carlson's results are due to an error in technique since the point of stimulation should be close to where the lever of the kymograph is attached. On *a priori* reasons one would expect a refractory period to occur in any automatic tissue and, since vertebrate skeletal muscle has a short refractory period (0.0015 sec.) and can be tetanized, there is no reason why the same should not apply to the invertebrate heart.

For many years there has existed the opinion that there is an immediate causal connection between automaticity and refractoriness, the latter state being conceived as one of "charge." This has recently been supported in a stimulating speculative article by Ritchie ('32). For the following reasons such an attitude should not be allowed to pass without challenge: 1. "In the same heart the parts possessing the greatest degree of automatism may exhibit a lesser degree of refractory state than the part of the heart not automatic," *e.g.*, the mud turtle (Carlson, '07). 2. "Refractoriness is exhibited by certain tissues that are not automatic under normal conditions," *e.g.*, the turtle ventricle (Carlson, '07). 3. "The motor nerve fibers to the frog's skeletal muscles exhibit a refractory period of 2/1,000 second; while some of the motor cells in the spinal cord of the frog show a refractory period of from 1/10 to 1/20 second. Yet these nerve cells exhibit no greater automatism than the motor nerve fibers. 4. Some of the pyramidal cells of the mammalian cerebral cortex exhibit refractory periods as long as 1/12 to 1/15 second. Yet these cells are not active automatically, at least as far as their motor functions are concerned" (Carlson, '06a).

7. *The all-or-nothing rule.* Hunt, Bookman, & Tierney (1897) considered that this rule is not applicable to the lobster's heart,

as it is, for instance to the frog and mammalian heart, since increase of stimulus increased the amplitude of the contraction or tetanus. Carlson ('03) held to such a view but later ('06b) noted that "the pulsating or quiescent heart (of Crustacea and Mollusca) *whose excitability and conductivity are but slightly impaired* [italics mine] responds by a contraction of uniform strength to stimuli of increasing intensity within a wide range, but an increase of intensity above this range is followed by beats of increased strength. . . ." Nothing in the above is serious evidence against the applicability of the all-or-nothing rule to the arthropod heart, but the results of Garrey & Knowlton ('34-35) on *Limulus* appear to be damaging. They obtained a summation of repetitive stimuli which yielded an augmentation of amplitude but not of frequency. The effects were shown to be purely motor and not afferent. Given a muscle area innervated by two different motor nerve fibers; when any one of these nerves is subliminally stimulated no augmentation is elicited but "we must still admit that the nerves are transmitting effects to the muscle otherwise it is difficult to explain the fact that stimulation of another nerve provokes an augmented effect." Even if one takes for granted that the heart muscle of *Limulus* is a syncytium, the results of the above investigators do not appear to be difficult to harmonize with the all-or-nothing rule. Thus, in his study on single with microelectrodes, Gelfan ('31, and elsewhere) was able to obtain localized contractions. These, however, are not accompanied by an electrical action potential, as is generally true for the all-or-none effects (Gelfan & Bishop, '32). It has, therefore, come to be accepted that the all-or-nothing rule is characteristic of the excitation process as distinct from the contractile one.

8. *Effects of various external agents.* a. *Perfusion liquids.* Modifications of Ringer's solution have been described for the intact heart of *Daphnia* (Lévy, '27), excised heart of *Astacus fluviatilis* (Dohrn, 1866, and Lévy, '33), *Cambarus clarkii* (Lindeman, '28), *Maia* and *Homarus* (Hogben, '25), and *Palinurus alandii* (Zoond & Slome, '28). Ordinary sea water is a fair perfusion medium for the hearts of poikilosmotic marine forms (Polimanti, '13; Fredericq, '22; Hogben, '25; Macallum, '26; Carlson, and others). Basing their figures on careful analysis of the blood

of the American lobster, Cole, Kazalski, & McComas ('38) adopted the following solution as best fitting the lobster heart: NaCl, 0.452; KCl, 0.015; CaCl₂, 0.025; MgCl₂, 0.004; MgSO₄, 0.004 (all in moles). Small amounts of NaOH were added to bring the pH to 7.4. With this solution the intact heart could maintain its vigor for 36 hours. Van't Hoff's solution and sea water were found to be poor perfusing media. With the former the heart could beat for about 1 hour; and with the latter up to 4 hours. All ideal perfusion media should be made up according to accurate analysis of the blood of the animal in question.

The intact heart of the stick insect, *Carausius*, and of the moth larva, *Cossus cossus* (A. Seliškar, unpublished, cf. Clark, '27), "beat well when irrigated with a fluid of the following molar composition: NaCl 0.22, KCl 0.002, CaCl₂ 0.001. Removal of Ca arrested the hearts in a few minutes, but removal of KCl produced no visible effects in 2 hours. Increase of KCl to 0.02 molar produced slowing of the rate of conduction . . . and arrested it in a few minutes. . . . Reduction of NaCl to 0.11 molar reduced the frequency of the heart. . . . The presence of K seems much less important for arthropod than for vertebrate hearts, and in many cases the heart functions normally in its absence. . . . Excess of K produces arrest." The reason these results have been quoted in full is because they are remarkable in view of the fact that the blood of insects is rich in potassium and contains sodium in relatively small amounts (Bishop, Briggs, & Ronzoni, '25; Brecher, '29; Drillhon, '34). It is, however, probable that the K is mainly present as unionized K urate.

b. *Various cations*.—(i) *Sodium, potassium, lithium, rubidium*. In isotonic NaCl the heart of the crawfish, *Palinurus* (Fredericq, '22; Zoond & Slome, '28) enters systolic arrest. One per cent and 2 per cent NaCl added to Lindeman's ('28) Ringer modification causes a marked increase in the rate and amplitude but a decrease in tonus of the contractions of the heart of *Cambarus clarkii*. Carlson ('06-'07, '08), whose results have shown that the deganglionated unhealthy heart of *Limulus* will not pulsate automatically, found that such a heart (like curarized vertebrate skeletal muscle, see the classic work of Loeb, 1899) twitches rhythmically in pure NaCl and that the rhythm may closely approach

the normal rhythm. If placed in normal sea water or plasma, after development of the "idio-muscular" rhythm, the contractions are quickly abolished. He suggested that NaCl may alter muscular tissue so as to make conductivity from cell to cell possible. Such a conclusion is no longer likely since we know that the healthy deganglionated heart, when adequately stretched, will pulsate rhythmically. It is possible that the effects of NaCl are not qualitative but solely quantitative, *i.e.*, *enhance* the conductivity from cell to cell.

Eventually pure NaCl brings the heart of *Limulus* and *Homarus* (Cole, *et al.*) to a systolic standstill. An analysis of the electrocardiogram, during the process of NaCl arrest has been made by Hoffmann ('11a).

Potassium, as 0.6 N KCl, is a primary stimulant (frequency and tonus) of the cardiac ganglion of *Limulus* (Carlson, '06e) but has opposite effects on a heart from which the ganglion had been removed. The same applies to rubidium. Lithium is a primary stimulant of the heart of the crayfish (Lindeman, '28) and is capable of only partially replacing sodium in a suitable Ringer's solution. Pure KCl, in the same concentration as in sea water, causes a primary decrease in frequency but an increase in amplitude of the heart of *Maia* (Polimanti, '13). The same is, however, also true for $MgCl_2$ (group II of the periodic table). It is the excess K in hypertonic Ringer's that produces a decrease in frequency and increase in amplitude of the heart beat of the crayfish (Cardot, '21, '22). Hogben ('25) noted that excess K, Na, or Rd first excites and then depresses the heart beat of *Maia* and *Homarus*, and that the eventual arrest is in diastole. Cæsium had no very marked effects. It is evident that ions belonging to group I of the periodic table (monovalent), when in isotonic solution, are primary stimulants.

(ii) *Calcium, magnesium, strontium, and barium.* An excess of Ca, Mg, or Sr causes a stoppage of the *Palinurus* heart in diastole; but Mg cannot be successfully substituted for Ca in the perfusion liquid (Zoond & Slome). Ringer's solution containing about 10 times the ordinary amount of Ca results in a decline in tonus and resultant swelling of the heart of *Daphnia* (Lévy, '27). Pure 0.6 N $CaCl_2$, $SrCl_2$, or $MgCl_2$ depresses the action of the

median dorsal cardiac ganglion and heart muscle of *Limulus* (Carlson, '06e) without any indications of primary stimulation. BaCl₂, on the contrary, is an intense primary stimulant of both.

The addition of 0.028 per cent SrCl₂ or BaCl₂ to the Ringer's solution for the perfusion of crayfish hearts (Lindeman, '28) causes an increase in tonus followed by an arrest in systole; but substituting 0.020 per cent SrCl₂ for the 0.024 per cent CaCl₂ in the usual perfusion solution results in maintaining the normal rhythm for five hours. Ca is a primary inhibitor of the heart of *Maia* (Polimanti, '13) and produces diastolic standstill (Hogben, '25).

Since a pure isotonic solution of Ca cations tends to produce cessation of the heart beat in diastole and a pure isotonic solution of Na ions cessation in systole, these two ions act antagonistically when together in solution. It is, therefore, not surprising that Zoond & Slome (*loc. cit.*) maintained rhythmic contractions of the heart of *Palinurus* in a solution containing only Na and Ca cations. Na and Ca also act antagonistically in their action on the cardiac ganglia, the former producing primary stimulation and the latter primary depression. The cations in both groups of the periodic table, as can be noted from what has been said, do not *all* act in accordance with their classification in the table. It may be said, however, that the monovalent metals antagonize the effects of the bivalent metals and that Na and K tend to stimulate nervous and muscular cells to activity while Ca, Mg, and Sr tend to depress activity. In fact, Loeb ('06) suggested that the periodic cessation of irritability in nerve or muscle, giving rise to rhythmic action, is due to the periodic substitution of Ca or Mg ions for Na or K ions, the ions passing alternately from the interior of the cell to the surface.

c. *Non-electrolytes*.—(i) *Urea, glycerin, and sucrose* have a primary stimulating action on the cardiac ganglion of *Limulus* (Carlson, '06e). The pulsations of the heart of *Palinurus* (Fredericq, '22) cease rapidly when the perfusion medium is sea water containing 2 per cent urea. In complete contrast, the heart of the dogfish (*cf.* Clark, '27) imperatively requires urea if it is to function normally. A vigorous cardiac ganglion of *Limulus*, inactivated by a pure isotonic solution of sucrose and again restored by

Limulus blood plasma or sea water, will, on a second bath in a sugar solution, come to rest in a much shorter time. The same results are produced by pure isotonic solutions of urea and glycerin. Carlson ('06d) hence stated that the theory which holds that the heart standstill is due to outward diffusion and dilution of the electrolytes about the cells (see Loeb above) fails to explain these facts for there apparently must be as many of them, qualitatively and quantitatively, during the restored rhythm as during the original if the heart pulsations are due to the presence of a definite quantity and ratio of electrolytes in the automatic tissue. A pure isotonic solution of sucrose may, however, have damaged the heart in some irreversible way.

(ii) *Adrenalin and thyroid extract*, in unstated concentrations, increase the heart rate of *Daphnia* (Hykes, '26). In a 1:100,000 conc. adrenalin may cause a slowing of the rate; in a 1:10,000 concentration, it may cause an acceleration both of the isolated and intact heart of *Daphnia* (Lévy, '27). It has a primary stimulating effect on the heart ganglion and heart beat of *Limulus* (Carlson, '06f, and Heinbecker, '36) and increases the frequency and tone of the heart of *Maia* (Hogben & Hobson, '23-'24).

(iii) *Pituitary and thymus extracts* slow the heart rate of *Daphnia* (Hykes, *loc. cit.*) but, in quantities comparable to those which exist in the mammalian uterus, pituitary extract has no apparent action on the excised heart of *Maia* (Hogben & Hobson, '23-'24).

(iv) *Anaesthetics* (ether, chloroform, chloretone, chloral hydrate, and ethyl alcohol) have, in weak concentration, a primary stimulating action on the cardiac ganglion of *Limulus* (Carlson, '06) and chloroform initially increases solely the amplitude of the cardiac beat of the lobster (Plateau, 1880). Chloral hydrate at once slows the heart rate of *Daphnia* (Lévy, '27) but raises the tonus slightly.

(v) *Alkaloids*. Strychnin, caffeine, curare, nicotin, atropin, cocain, pilocarpin, physostigmin, aconitrin, veratrin, saponin, quinin, digitalin, adrenalin, and ergot have, in weak concentration, a primary stimulating effect on the cardiac ganglion of *Limulus* (Carlson, '06f, '22, and Heinbecker, '36). They paralyze or block the cardio-inhibitor nerves but not the cardio-augmentor

nerves (Carlson, '22). The paralysis of the heart tissues that ensues occurs in the following order: ganglion, motor plexus, muscle (Meek, '08). Acetylcholin (1-500) has a primary depressant action and will cause a cessation of spontaneous activity in 15 minutes (Heinbecker, *loc. cit.*).

Nicotin, applied to the heart of the roach or of larvæ of the moth *Prodenia eridamia* (Yeager & Gahan, '37), in concentrations varying from 0.0005 to 10 per cent by weight, "causes initial stimulation followed by partial depression at relatively intermediate concentrations and stimulation followed by complete depression and paralysis at relatively high concentrations." The effects were generally reversible. Nicotin is known to decrease the ability of striated muscle to recover from the contracted state and thus evokes systolic arrest of the insect heart (Yeager, '38).

Even in large doses, curare did not paralyze cockroaches or beetles (Moseley, 1871) and, in Crustacea, the action of curare is reputedly slower than it is among vertebrates (Yung, 1878, Plateau, 1879, 1880; Lapicque & Lapicque, '10, '36).

Digitalin, atropin, caffenin, veratrin, and nicotin, in weak concentration, have a primary stimulating action on the heart of Crustacea (Yung, 1878; Pickering, 1878; Plateau, 1880) but muscarin, theobromin, and xanthin have no apparent effects on the heart of *Daphnia* (Pickering, *loc. cit.*).

d. *Hydrogen ions*. The arthropod heart can function normally within a relatively wide pH range. The optimum pH for the excised heart of *Palinurus* (Zoond & Slome, '28) in a balanced solution of only Na and Ca chlorids is 5.0. On the alkalin side it loses tone at about pH 8.0 but is not tolerant of slightly greater acidity than pH 5.0. The rhythm of the excised heart of a crayfish has been stated to be normal within the pH range of 5.5 to 9.0 in Lindeman's ('28) perfusion medium. At pH's a little below 5.5 there was an increase in tone but a decrease in the amplitude and frequency. Six-tenths N HCl has a primary stimulating effect on the cardiac ganglion and a primary depressant action on the heart muscle of *Limulus* (Carlson, '06c). Six-tenths N KOH has a primary stimulating effect on both the heart muscle and cardiac ganglion of *Limulus*. At pH 3 there is a marked decrease in the frequency of the heart of trichopterous larvæ. The effects are reversible if not prolonged (Krey, '37).

e. *Carbon dioxide* poisoning causes diastolic standstill of the heart of *Limulus* (Newman, '06). If the condition is not prolonged recovery is rapid. The heart muscle is less sensitive than the cardiac ganglion.

f. *Oxygen lack*. The cardiac ganglion of *Limulus* (Newman, *loc. cit.*) will retain its activity unimpaired, when in a very deficient oxygen supply, for several hours. Lowering the oxygen pressure of the perfusion medium decreases the heart rate in the decapods (Plateau, 1880).

SUMMARY

1. The circulatory system of arthropods is of the open type. This means that the aorta and arteries, when the latter are present, open into the hæmocœle. Most arthropods have no veins, or sinuses, but some Crustacea (*e.g.*, amphipods and læmodipods) do have veins though no arteries other than the dorsal aorta. The veins open distally into the hæmocœle and communicate proximally with the pericardial sinus.

2. Blood is aspirated into the pericardial sinus during the diastolic phase of the heart beat. The alary muscles of the dorsal diaphragm, by stretching the heart muscle, augment this effect. The extra-arterial pressure in the limbs of arthropods is less than atmospheric.

3. The gills of the crab do not offer much resistance since they lower the blood pressure through only 6 mm. of water. In arthropods which respire by way of gills or lung-"books," the blood must pass through such directly before entering the heart. This implies that the heart is in the same transverse region of the body as the gills or lung-"books" (*e.g.*, in the thorax in amphipods and in the abdomen in stomatopods). In those whose blood has no significant respiratory function the heart is located in the same transverse region of the body as that of the food-absorptive portion of the gut (*e.g.*, the abdomen in insects).

4. Since circulation is of the open type, movements of the viscera and skeletal muscles greatly enhance the circulation.

5. The heart of many arthropods (*Peripatus*, *Limulus*, scorpions, spiders, many crustaceans, and "myriapods") is supplied either with a median dorsal ganglion, or, as in cockroaches, with

a chain of ganglion cells on each lateral side. The heart of dragonfly larvæ is innervated solely by a pair of large lateral axons. The intrinsic cardiac ganglia receive nerve fibers from the central nervous system and give off efferent nerve fibers to the heart muscle and receive afferent fibers from such. The hearts of certain Crustacea, in contrast to those of *Limulus* and insects, contain ganglion cells scattered in their walls.

6. The heart of many arthropods has been shown to be supplied by inhibitor and augmentor fibers. In *Limulus*, at least, the action of these nerves is directly on the intrinsic cardiac ganglia.

7. The heart beat of adult *Limulus*, isopods, scorpions, and probably spiders is normally neurogenic. Myogenic automatism is, however, possible if the heart muscle is adequately distended.

8. The heart beat in *Limulus*, lobster, and vertebrate embryos is myogenic. So is the heart beat of dragonfly larvæ.

9. The pacemaker is usually at the posterior end of the heart. But there is a continuous shift and, in certain instances, reversals occur at regular intervals.

10. The tetanus of the heart muscle of arthropods is the result of a summation of several fundamental contractions. This is made possible by a not too long refractory period.

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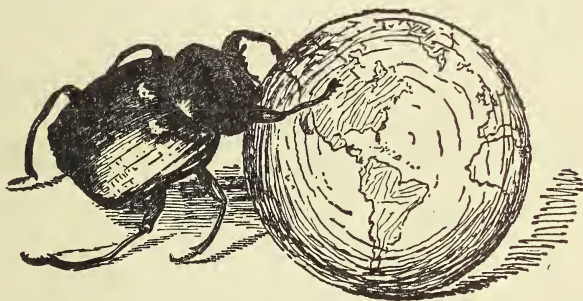
DECEMBER, 1939

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No. 4

NEW CICADAS FROM NORTH AMERICA AND THE WEST INDIES

BY WILLIAM T. DAVIS

STATEN ISLAND, N. Y.

Owing to the uncertainty of getting specimens, the Cicadidæ were the last group of large and conspicuous insects in North America to receive more than passing attention from entomologists. Some species are still known from but one or two individuals, and no recently collected examples of others have been seen by the writer for a number of years. Some of these, while large and conspicuous, have a rather restricted distribution. Then there is the fact that their life cycle is not known except in *Magicicada*, leaving it a matter of uncertain fortune as to whether they are found or not even when their known habitats are visited. It will be some years before there are sufficiently large collections so that the species from each of the states can be definitely listed as they have been in a few of the smaller eastern and central states. It will also take some years to acquire an accurate knowledge of the status of many of the forms, which can finally be accomplished by observing them in life; the plants that they prefer if any; their songs, their associations and general behavior.

In the preparation of the present article, I am indebted to Mr. Paul W. Oman of the U. S. National Museum and to August Busck and H. S. Peters, who collected a number of the specimens received from that museum; to Mr. W. E. China for making numerous comparisons with cicadas in the British Museum; to Dr. Raymond H. Beamer of the University of Kansas, and to the State College

of Washington at Pullman, for cicadas from the northwest; to Prof. H. Frere Clement and Brother Chrysogone for numerous specimens from Cuba; to Mr. and Mrs. John L. Sperry, to Arthur T. McClay, as well as to Warren Condit for taking photographs, and to Mrs. Muriel Mattocks Cleaves for drawing the text figures.

***Fidicina panamensis* new species (Plate II, Fig. 2)**

Type male and allotype female from Tabernilla, Canal Zone, Panama, May, 1907 (Aug. Busck collector). Collection, U. S. Nat. Museum.

Resembles *Fidicina compostela* Davis (Plate II, Fig. 1) described and figured in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, March, 1934, in color, and in the considerable amount of brown at the base of both fore and hind wings, but is generally smaller, eyes not as prominent and with the front of the head more evenly and symmetrically rounded. The sides of the pronotum are fringed with many rather evenly placed short bristles, not present in *compostela*, but found in *viridifemur* from Brazil. The forward extension of the tymbal covers are rather sharply pointed in *compostela*, and more inwardly curved with a rounded extremity in *panamensis*. Opercula short and truncate with the outer and lower margins less sinuate than in *compostela*. Last ventral segment gradually rounded to the extremity, which has a shallow notch in the male; in the female the notch is of considerable size. Underside of the abdomen with the segments somewhat translucent, permitting in the males, and under strong light, of an indistinct view of some of the interior structures. Underside of the body including the valve with numerous hairs. Uncus as figured.



Fidicina panamensis

Body of a general brown color. Head greenish orange with the black band connecting the eyes narrower than in *compostela*. Pronotum nearly a uniform, pale, brownish green, with the fore margin irregularly blackened, and the hind margin or collar greener. Mesonotum of the same color as the pronotum, with four nearly black obconical spots extending backward from the front margin; inner pair about half the length of the outer pair. Cruciform elevation brownish green with an irregular dark spot in the hollow between the anterior limbs. Abdomen with the segments inconspicuously black anteriorly, edged with brown posteriorly, and with areas of golden pubescence, particularly on the sides. Legs pale orange. Both pairs of wings clear ex-

cept at base, where they are irregularly browned and chestnut colored. Basal area opaque but not as strongly so as in *compostela*.

MEASUREMENTS IN MILLIMETERS

	Male Type	Female Allotype
Length of body	23	22
Width of head across eyes	9	9
Expanse of fore wings	72	75
Greatest width of fore wing	11	11
Greatest width of operculum	5	.....

In addition to the type and allotype, 14 males and 3 females, collected at Tabernilla, Canal Zone, Panama, from April 27 to June 1, 1907, by Mr. Busck, have been examined, also a single female collected by Mr. Busek at Port Bello, Panama, April 21, 1912. Mr. W. E. China stated in commenting on the specimen sent for comparison in the British Museum that what we here call *panamensis* is related to *F. viridifemur* Walker, as well as to *F. compostela* Davis.

Genus *Uhleroides*

There are five species of cicadas in Cuba that resemble one another in size, in being generally green or greenish in color, and in having the bodies and fore wings marked with fuscous. *Uhleroides cubensis* Distant, described in 1912 and figured in *Genera Insectorum*, 1914, plate 2, is the type of the genus, and while the tympanal coverings are conspicuous in *cubensis* and distinguish it, the females of all the five species bear a striking resemblance to one another. The shape of the male uncus is so nearly uniform that it does not provide a ready means by which the species may be separated.

Mr. W. E. China has kindly compared specimens sent to him with cicadas in the British Museum, and suggests that all of them be placed in the genus *Uhleroides*. Two of them have been placed in the genus *Odopœa* in Distant's catalogue in 1906, but in *dilatata* Fabricius, the type of that genus, the pronotum is greatly expanded at the sides and extends forward close to the eyes. The abdomen of the female is more parallel sided than in *Uhleroides*,

and more suddenly or abruptly attenuated toward the extremity. In *Uhleroides* the abdomen of the female tapers gradually.

Uhleroides chariclo Walker, was described in 1850, and is the *Proarna chariclo* of Distant's catalogue of 1906. The original description contains the statements: "hind scutcheon [collar] narrow above widened and almost angular above the base of the fore wing," and "fore thighs armed with three teeth, the first rather long, very oblique, second of moderate size, third rather small." The size given is length of body 9 lines, expanse of wings 28 lines.

One hundred and two males and 50 females, collected by Brother Chrysogone in Pinar del Rio province, western Cuba in June, July and August, have the sides of the pronotum rounded or "almost angular" in all but one, which has the sides noticeably angulated. The fore thighs are armed as described. The tympanal coverings are pointed at the extremity in this small and greenish species. In "Histoire De Cuba, La Sagra," Guerin states that Walker had but a single male when he drew up the description of *chariclo*, and that he personally had seen no examples of the species.

Uhleroides walkeri Guerin was described in 1857, and is the *Odopæa walkeri* of Distant's catalogue. The original description states that the sides of the prothorax are: "acutely dilated" and "form an acute angle at the middle." Also that the anterior femora are: "bidentate beneath." The length is given as 19 and the spread as 57 millimeters. Guerin noted a considerable variation in the four specimens seen by him from Cuba.

As in *chariclo* there is usually a small third spine on each of the anterior femora, which must have been overlooked by Guerin. In 89 specimens from Holguin, Guantanamo, and the Sierra Maestra near Santiago de Cuba, all in eastern Cuba, the prothorax is acutely dilated at the sides, and the tympanal coverings are pointed. The spread of wings may vary from 60 to 70 millimeters.

The accumulation of additional specimens from intermediate localities may show that two species are here included under *walkeri*. Both it and *chariclo* were recognized by Uhler, 1892, in: "Preliminary Survey of the Cicadidæ of the United States, Antilles and Mexico."

Uhleroides sagræ Guerin was described in 1857, and appears in Distant's catalogue next to *walkeri*. It is described as yellowish green variegated with black, prothorax green at the sides and behind; rounded and not with an acute angle at the middle as in *walkeri*. The length is given as 24 to 28 and the spread as 78 millimeters. It is said to be much larger than *walkeri* and to have the anterior femora "unidentate beneath."

In a considerable series of 292 specimens from western Cuba collected in July and August by Brother Chrysogone, a single male was found with the sides of the pronotum angulated, while several showed a slight angulation. The fore femora may occasionally be armed with three spines as in the other species. Three females from Baracoa in Oriente province, extreme eastern Cuba, have the sides of the pronotum unangulated and much less dilated at the anterior angles than in the western specimens. *Sagræ* is usually much larger than the four other species of *Uhleroides* from Cuba here considered, some reaching a spread of wings of 85 millimeters. Also the fore wings are usually more heavily spotted. The tympanal coverings are ample, with the forward projection rounded at the extremity and not pointed as in the generally smaller and usually greener species already mentioned.

Uhleroides cubensis Distant, was described in Ann. and Magazine of Natural History, S. 8, Vol. IX, 1912, from a male and figured in "Genera Insectorum," 1914, plate 2. *Cubensis* may be told by having the "tympanal coverings globose and projecting beyond the lateral margins of the abdomen, outwardly complete, the orifices only exposed inwardly," as mentioned in the original description. It has the base of all of the wings plainly brownish or chestnut colored (ochraceous in original description), while in *chariclo*, *walkeri*, *sagræ*, and the new species here described, the color is gray and white. "Abdomen beneath piceous, the lateral margins broadly ochraceous" according to original description, but in the 19 males in the writer's collection from western Cuba, the abdomen beneath has a piceous stripe, while the lateral margins are broadly pruinose.

In eastern Cuba there appears to be a separate species allied to *cubensis* and here described as new.

***Uhleroides mæstra* new species (Plate II, Fig. 3)**

Type male from near Santiago de Cuba, July, 1938 (H. Frere

Clement), and allotype, female, Loma del Gato, Oriente, Cuba, August, 1939. Davis collection.

Sides of the pronotum expanded less than in *cubensis*, especially at the anterior angles. The tymbal covers, though ample as in *cubensis*, are less globose and do not project as far beyond the lateral margins of the abdomen.

The general color is greenish with less pale brown than in *cubensis*, and the greenish tymbal covers without the fuscous marks at the apical angles. The fuscous marks on the head and pronotum (which has a green collar), as well as on the mesonotum, are arranged as in the other species of the genus known from Cuba. Beneath greenish, lacking the broad fuscous central stripe with pruinose margins found in *cubensis*. First, second and third cross veins of the fore wings are infuscated, and there is a row of marginal spots, one at each vein. Both fore and hind wings gray and white at base, as in *chariclo* and *walkeri*, and not brownish or chestnut colored as in *cubensis*.

MEASUREMENTS IN MILLIMETERS

	Male Type	Female Allotype
Length of body	18	18
Width of head across eyes	6	6.5
Expanse of fore wings	55	60
Greatest width of fore wing	8	8
Greatest width of operculum	5	...

In addition to the type and allotype a larger male paratype with wings expanding 63 millimeters, collected at the same place and date as the type, is in the writer's collection, as well as a male and female from Loma del Gato, collected in August, 1939. A very large male with wings expanding 70 millimeters, from the upper Ovando river, eastern Oriente, July, 1936 (Darlington) is in the collection of the museum of Comparative Zoology.

Uhleroides hispaniolæ new species (Plate II, Fig. 4)

Type male and allotype female, San Francisco Mountains, St. Domingo, W. I., September, 1905 (August Busck) U. S. National Museum.

Resembles in size and greenish color *Uhleroides walkeri* from eastern Cuba, but lacks the acute angle at the dilated sides of the pronotum. The tymbal covers have the forward projection broad and more evenly rounded at the forward extremity than in *sagræ*, and without the sinuation on the inner side found in that species—they are not acutely pointed as in *walkeri*.

The tymbals are exposed on the inner side only and the covers do not protrude beyond the sides of the abdomen. The front of the head evenly rounded and about as broad as the front of the pronotum. Anterior femora armed with three spines, the central one prominent. The opercula short and rounded as in *sagræ*, *walkeri* and *cubensis*, but with the inner extremities slightly overlapping.

The pronotum has the collar green with the fuscous marks on it, as well as on the head and mesonotum, arranged as in the several Cuban species of *Uhleroides*. Like *walkeri* the central obconical marks on the mesonotum are more prominent than in *sagræ* and *chariclo*. The tergum of the abdomen is brownish, each segment margined posteriorly with green, and there are two rows of spots which converge and become blended together as the end of the



Uhleroides hispaniolæ

abdomen is approached. Beneath, greenish, and spotted with fuscous as in other members of the genus. First, second and third cross veins of the fore wings are infuscated and there is a row of marginal spots, one at each vein, while between the veins and running parallel to them, there are pale infuscated lines also present in the paratypes. The allotype has the margin of the fore wings clouded.

MEASUREMENTS IN MILLIMETERS

	Male Type	Female Allotype
Length of body	21	20
Width of head across eyes	7.5	7
Expanse of fore wings	65	65
Greatest width of fore wing	9	9
Greatest width of operculum	5	.....

In addition to the type a male paratype from the Distant collection in the British Museum has been sent by Mr. W. E. China. It is labeled St. Domingo, and is like the type. In both it and the type, on account of injury, the uncus cannot be figured or described. In the U. S. National Museum there are also two female

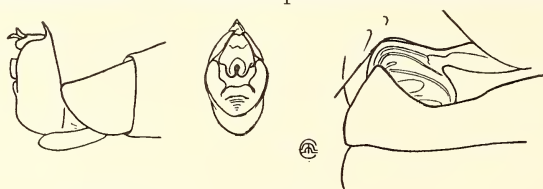
paratypes labeled St. Domingo, W. I., August (Aug. Busck collector).

***Uhleroides samanae* new species (Plate II, Fig. 5)**

Type male, San Francisco Mountains, St. Domingo, W. I., September, 1905 (August Busck). U. S. National Museum.

Resembles in general appearance *U. hispaniolæ*, but the tymbals are exposed on both the inner and outer sides, the forward projection of the cover being narrowed into a rather acute point as in *walkeri* of eastern Cuba. The dilated sides of the pronotum are not sharply angulated as in *walkeri*, but are more evenly rounded, as in *hispaniolæ*, or the much larger *sagræ*. It differs from all the species of *Uhleroides* so far examined in having the ends of the horse-shoe shaped uncus bent inward and touching; in the other species, the extremities are separated. Males of *hispaniolæ* with the uncus complete, have not been available. Front of the head evenly rounded, and about as broad as the front of the pronotum. Anterior femora armed with three spines, the central one prominent and the third very small. The opercula short and rounded with the inner extremities not touching as in *hispaniolæ*.

Pronotum green, with the grooves in front of the collar fuscous. The central pair of obconical marks on the mesonotum prominent and touching at the base; the outer pair broken and about half as long as the inner pair. A fuscous spot each side of the X, and an inner pair of spots included between its forward extremities. The anterior portion of the mesonotum pale brown;



Uhleroides samanae

posterior about the X greener. The tergum of the abdomen brownish, each segment margined posteriorly with green. Beneath greenish. First and second cross veins of the fore wings but slightly infuscated; the row of marginal spots, one at each vein, are but faintly represented and no pale parallel lines between the veins.

MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body	24
Width of head across eyes	8
Expanse of fore wings	70
Greatest width of fore wing	10
Greatest width of operculum	6

In addition to the type, there is in the collection of the U. S. National Museum, a broken female labeled: "Port-au-Prince, Haiti, Nov. 26, 1928," that appears to belong to this species.

A NEW CICADA FROM THE BAHAMA ISLANDS

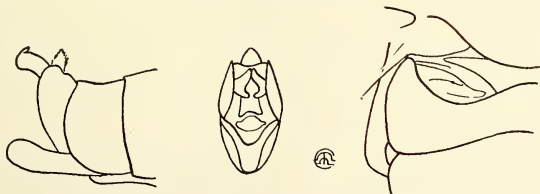
In the U. S. National Museum there are six cicadas collected in July and August, 1930, by H. S. Peters, that appear to belong to the same species although from five different islands of the Bahama group, British West Indies. Through the courtesy of Mr. Paul W. Oman I sent a specimen to the British Museum for comparison, and Mr. W. E. China stated that it was apparently an undescribed species. Owing to the broad head it is here considered under *Ollanta* rather than under *Proarna*, to which it is also related, particularly in venation. In *Proarna* the head across the eyes is narrower than the anterior margin of the pronotum (See JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, March, 1928, plate 1).

Ollanta caicosensis new species (Plate II, Fig. 6)

Type male, South Caicos Island, British West Indies, July 29, 1930 (H. S. Peters). U. S. National Museum.

Head broader than the anterior margin of the pronotum, but the front not quite as produced as in *Ollanta mexicana* and *O. modesta* from Central America. Tymbals exposed on the inner side only; the forward extension of the covers ending in a blunt and rounded point, not as pointed as is usual in *Proarna*. Opercula short and rounded, but with the extremities somewhat truncated. The interior angles not touching, but nearly touching in some of the paratypes.

General color pale brownish, somewhat greenish on the pronotum. Head with a narrow, irregular black band across the front at the antennæ, and a much broader band between the eyes in which the ocelli are included. Pronotum with the grooves blackened, and a black spot centrally at the margin of the collar. Collar with a fuscous spot each side at the anterior angles. Pronotum with the central pair of obconical spots about half as long as the



Ollanta caicosensis

outer pair which are composed of lacerated spots. Two distinct spots between the anterior limbs of the X. Abdomen with about the basal half of each segment black; blackened at the base in the region of the tympana, and covered generally with an appressed pubescence.

Beneath pale and pruinose, the front with the transverse rugae somewhat blackened. Legs, opercula and abdomen straw-colored, the last the darkest. Fore wings with the venation pale; first, second and third cross veins infuscated, and the veins at the marginal areas heavily infuscated near their extremities. Close to the outer margin of each fore wing there are six or seven small fuscous spots, one between each of the veins at the outer limit of the marginal area. The basal area is clear, and the basal membranes of both pair of wings are almost white. Some species of *Proarna* have the fore wings spotted as here described but to a much less degree.

MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body	22
Width of head across eyes	8
Expanse of fore wings	59
Greatest width of fore wing	8.5
Greatest width of operculum	4

In addition to the type there are five male paratypes labeled as follows: Acklin's Island, July 9, 1930; E. Caicos Island, July 27, 1930; S. Caicos Island, July 29, 1930; W. Caicos Island, August 4, 1930, and Great Inagua Island, August 9, 1930, all collected by H. S. Peters. When larger collections are made it will probably be found that the cicadas from each of the several islands show some slight differences. The male from Great Inagua Island is most unlike the others, and it is the most distant island.

Psallodia espinii Uhler (Plate II, Fig. 9)

In his paper "A New Cicada from Hayti," Trans. Maryland Acad. of Sciences, 1903, p. 18, Uhler states in the original description of the genus and species: "Two male specimens of this neat little species were secured for me in the vicinity of Port de Paix, Hayti, by Dr. Joseph Espin."

In the collection of the U. S. National Museum the writer has examined a male labeled: "*Psallodia espinii* Uhler, Haiti Det. Uhler," and a male: "Port de Paix, Haiti." There can be no

doubt but what these are the two males referred to by Uhler, and the first mentioned can be considered the type of the genus *Psallodia*, and of the species *espinii*, as described by him in 1903.

Under *Melampsalta*, on page 163 of his catalogue of 1906, Distant states: "*Psallodia*, Uhler, apparently belongs to this division, but I have not seen a specimen." While Uhler stated that *Psallodia* is: "Similar in form to *Melampsalta* Stal," he also recorded: "basal areole long, narrow, attached to radial vein beyond the base, emitting the two approximate ulnar veins diagonally from the outer angle." Emitting two approximate ulnar veins precludes it from *Melampsalta*, where the median and cubitus veins unite near base of fore wing and reach the basal cell or arculus as a single vein. The lower ulnar vein (cubitus) is remarkable for its upward arch or bend in *espinii*, found to like degree in few cicadas. The manner in which it and the median vein join the basal cell, is as in the genus *Taphura*, and it is likely that *Psallodia* should be placed near that genus. A dorsal spine terminates the abdomen in both the male and female of *Psallodia espinii*, as is also the case in *Taphura* to be found in Barro Colorado Island, Canal Zone; in Venezuela, Brazil, Paraguay, and elsewhere in South America.

Psallodia espinii is represented in the writer's collection by a male, here figured, and a female, both from Post Chaubert, Le Trou, Haiti, June 4, 1927 (G. N. Wolcott).

Okanagana fumipennis Davis

This distinct species was described and figured in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY for June, 1932. It was recorded from Colorado, New Mexico and Utah, as occurring on sage brush and juniper.

On June 21, 1937, Mr. John L. Sperry and Mrs. Sperry found a single colony of *fumipennis* 35 miles north of Williams, Coconino County, Arizona, on the Grand Canyon road. The cicadas were singing and found in but one area. They were on low scrub one to two and a half feet high among rather scattered cedars, but the cicadas were all in low brush. "I tried at the time to identify the brush," writes Mr. Sperry, "but did not recognize the dead bushes in which we found the cicadas."

This adds Arizona to the known distribution of *fumipennis*, which, while resembling *Okanagana schaefferi*, may be separated by its thickened venation and by having the wings milky and clouded.

OKANAGANA LURIDA AND RELATED SPECIES

Okanagana lurida Davis was described and figured in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, September, 1919, from a single male collected at Pullman, Washington (C. V. Piper), and later the type was placed in the collection of the U. S. National Museum. In the same JOURNAL for June, 1936, additional specimens of *lurida* are recorded. Lately Mr. Paul W. Oman has sent several from the collection U. S. National Museum for examination. They came from Pullman, Wawawai, Steilacoom and Yakima in Washington, and one was collected in Oregon. While these were being examined I received, through the courtesy of Dr. Raymond H. Beamer, fifty specimens collected at Pullman, Washington, in June, July and August; one without locality label, and one from Wawawai. They were from the collection of the State College of Washington located at Pullman. I have also examined a male *lurida* from Moscow, Idaho, July 8, 1937 (T. A. Brindley), collection University of Kansas. It appears from this series that *lurida* inhabits the water-shed of the Snake River and vicinity.

As was stated in the original description *lurida* resembles in color *Okanagana vandykei* Van Duzee, known from California and Oregon, but is smaller and differs in the shape of the uncus. It also resembles *Okanagana ferrugomaculata* from California and Oregon, but the wings are narrower in that species, which also has a differently shaped uncus as figured in this JOURNAL, June, 1936, p. 110. In size and some other characters *lurida* more nearly resembles the pale examples of *Okanagana occidentalis* and *Okanagana bella*. As in *occidentalis* there are usually many very short bristly hairs on the head, but the lateral margins of the pronotum are very rarely black. I have seen but one specimen so colored. The pronotum is usually edged all around with pale as in *bella*, and the notch in the last ventral segment of the female is often as in *bella* without an inner notch present in *occidentalis*. In some specimens there are indications of an inner notch. In its size and

pale venation, *Okanagana arboraria* Wymore, from California, resembles *lurida*, but the front of the head is much less prominent, as is also the case in *O. ornata* Van Duzee.

***Okanagana yakimaensis* new species (Plate II, Fig. 7)**

Type male, Yakima, Washington, July 10, 1903. Collection, State College of Washington, Pullman, Washington.

A dull straw-colored insect with the front of the head protruding but more evenly rounded in front than in *lurida*, *bella* or *occidentalis*.

Head narrow; hairy both above and beneath and eyes not prominent. The uncus as figured. Color almost entirely dull straw-color. Head straw-color, eyes darker; pronotum straw-color, a dark spot each side at the extremity of the collar; mesothorax uniformly straw-color with an indistinct dark spot



Okanagana yakimaensis

in the hollow each side of the lower limbs of the X; tergum straw-color, with a short and dull colored dark mark each side on segments 3 to 7. Uncus and valve pale and hairy. Abdomen, beneath hairy, straw-colored, with the usual dark area at base. The venation of the wings uniformly pale, with the membranes at base of both pair pale pink, and of the same color as in the palest examples of *lurida*. The front wings have a basal dark dot, present in some other pale winged *Okanagana*.

MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body	24
Width of head across eyes	6.5
Expanse of fore wings	60
Greatest width of fore wing	10
Length of valve	3

A paratype collected at the same place (North Yakima now known as Yakima) as the type, is in the writer's collection, and is like the type.

In April, 1920, a male *Okanagana* in the collection, Museum of Comparative Zoology, Cambridge, Massachusetts, labeled:

"Yakima City, W. T., July 2-4, 1882," was examined and photographed. At that time the following memorandum was made: "Almost wholly straw colored above; a dark oblong spot each side on the pronotum near the humeral angles; a dark spot in the hollow each side of the mesonotal X, and the 3, 4, 5, 6 and 7 abdominal segments with a black streak each side along the base. Beneath it is straw colored with the usual dark mark near the base of the abdomen. The legs are entirely pale. The insect seems to be mature." From the photograph and this description made independently and previous to the receipt of the type from the collection of the State College of Washington, it appears that the 1882 specimen is referable to *yakimaensis*. As in other *Okanagana*, this insect may occur in a darker form than here described.

***Okanagana mariposa* variety *oregonensis* new variety**

The species was described in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY for March, 1915, from Mariposa County, California, as largely black in color decorated with orange. It is a large narrow-winged insect expanding from 70 to 80 millimeters, with a broad head, the front of which is not prominent. The uncus is not hooked at the extremity as in *Okanagana simulata* from Southern California, which it otherwise resembles in size and color. The basal membranes of all of the wings in *mariposa* are orange in color, and the basal areas of the fore wings are opaque. While the different broods show slight color differences, they are on the whole remarkably uniform as shown by the 163 specimens in the writer's collection, found from Southern California to Oregon, as well as in Arizona and Utah.



O. mariposa var. *oregonensis*

Recently Mr. Arthur T. McClay sent a male and female of *mariposa* representing a color variety having the membranes of all of the wings greenish-white instead of orange. For this variety the name *oregonensis* is here proposed. The male type (Plate II, Fig. 8) and female allotype were collected at Oregon Caves, Oregon, June 7, 1938.

Variety *oregonensis* strongly resembles in color the smaller *Okanagana albibasalis* Wymore, described in the Pan Pacific

Entomologist, October, 1934, p. 167, and now known from Shasta County southward to Orange County, California. *Albibasalis* expands about 65 millimeters, the basal area of the fore wings is clear instead of opaque, and the wings are proportionately broader than in *mariposa* and its variety. The uncus in *mariposa* terminates rather bluntly (truncate), and the upper and lower surfaces are more parallel than in *albibasalis*.

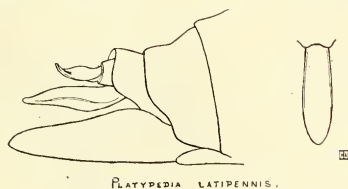
***Platypedia affinis* new species (Plate II, Fig. 10)**

Type male, Price, Carbon County, Utah, June, 1937 (C. E. Burt). Collection, U. S. National Museum.

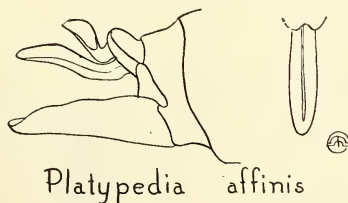
Resembles *Platypedia latipennis* Davis in size, in the blue color reflections of the body, and in having broad wings, but differs in the shape of the uncus and in several color characters.

Front of the head not very prominent; median sulcus well defined and centrally broadened on the face. The whiteish hairs on the body are numerous; the upper surface is nearly smooth except on the head and about the mesonotal X, while beneath the hairs are long and numerous. The fore wings have eight apical cells; are very broad, and have the costal nerve rather suddenly bent near the end of the radial cell. When viewed from in front the costal margin is seen to be wavy, suggesting an approach to *Neoplatypedia*. The uncus is considerably arched at the top, more so than in *latipennis*, and with the dorsal line rather suddenly bent downward near the extremity. The lower line of the uncus is more parallel to the upper surface than in *latipennis*, and follows the curve of the arch except near the extremity.

General color blue black, with the lighter marks pale orange to straw color, instead of brilliant orange-red as in *latipennis*. Fore femora entirely black, except the extremities, which are straw color; middle and hind femora black above, and pale beneath. The pronotum has a central pale line joining the



PLATYPEDIA LATIPENNIS.



Platypedia affinis

straw colored front margin, and the hind margin or collar is more broadly pale in color. The hind margin of the mesonotum is pale each side of the black X. Metanotum edged with pale orange. Tergum shining blue black. Uncus black with an inconspicuous pale dorsal line; valve black. Costal margin of the broad fore wings pale to end of radial area; the venation of the fore wings otherwise darker or fuscous. Membranes at base of fore wings pale orange; at base of hind wings much paler. In *affinis* the venation of the hind wings is straw color except the marginal vein; in *latipennis* it is red except the darker marginal vein. In *Platypedia barbata*, which also has broad wings, the body is more hairy, and has brassy reflections instead of blue.

The figure of the genitalia of *Platypedia latipennis* is here reproduced for comparison from the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, March, 1921.

MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body	18
Width of head across eyes	5
Expanse of fore wings	41
Greatest width of fore wing	8.5
Length of valve	4

A paratype collected at the same place and time as the type, is in the writer's collection, and is like the type. The right eye unfortunately has been damaged which makes the head appear narrower than in the type.

PLATE II

- Figure 1. *Fidicina compostela* Davis, 1934. Type.
- Figure 2. *Fidicina panamensis*. Type.
- Figure 3. *Uhleroides mæstra*. Type.
- Figure 4. *Uhleroides hispaniolæ*. Type.
- Figure 5. *Uhleroides samanæ*. Type.
- Figure 6. *Ollanta caicosensis*. Type.
- Figure 7. *Okanagana yakimaensis*. Type.
- Figure 8. *Okanagana mariposa* var. *oregonensis*. Type.
- Figure 9. *Psallodia espinii*. Uhler.
- Figure 10. *Platypedia affinis*. Type.



CICADIDÆ

AN EARLY ENTOMOLOGICAL BOOK FOR CHILDREN

BY HARRY B. WEISS

In 1819 there was published in London a work of 408 pages entitled "Dialogues on Entomology, in which the Forms And Habits of Insects are Familiarly Explained." This was illustrated with twenty-five engraved plates and printed by Charles Wood of Poppin's Court, Fleet Street, for R. Hunter, "Successor to Mr. Johnson, No. 72, St. Paul's Churchyard." There is no indication either on the title page or within the pages, of its author. Thirty-seven years after its publication, a Robert Hunter of Edinburgh was the author of a note in the *Zoologist* (14, 1856, p. 5214) on the "Singular effect of fascination on a fly," in which there is described the supposed fascination which a scorpion exerted upon a muscid fly in Central India, but there is nothing to indicate that this Robert Hunter was the same one who published the "Dialogues."

Joseph Johnson, the predecessor of R. Hunter, was one of the leading publishers of London. He brought out the writings of Priestly, John Newton, was friendly with Erasmus Darwin and published his work, and was highly thought of by William Cowper, who found him fair and judicious until their relations became less cordial as a result of a financial disagreement over a translation of Homer, which Cowper issued by subscription. However, Johnson had a reputation for honesty and integrity and his views were advanced. At one time he was in prison for nine months for publishing prohibited works of Gilbert Wakefield. He was associated with William Blake and brought out Blake's work on "The French Revolution." To John Henry Fuseli's "Milton Gallery," he was a generous subscriber. Fuseli, a painter, was interested in entomology, and one of his brothers, Caspar, wrote upon entomological subjects, to the extent of twenty-five titles.

In the preface to the "Dialogues," which was supposed to be for children around eight or ten years of age, the idea is ex-

pressed of the need for keeping infant minds constantly employed and guided. Natural history, including the study of entomology, was supposed to be well suited for this purpose, being easily kept down to the capacity of any age, and presenting interesting facts for amusing the senses without putting an undue strain upon the mind.

With this purpose in mind the unknown author wrote the "Dialogues" because of the absence of popular works on the subject and because he believed that it was possible to blend technical language with interesting descriptions in a way that would not discourage young readers. He pays a tribute to Kirby and Spence's "Introduction," but thought it was beyond the comprehension of little students.

The book is dedicated, "with sentiments of esteem, gratitude, and affection to 'Miss Edgeworth,' from whose writings the youth of the present age have derived equal entertainment and advantage." To students of children's literature the name of Maria Edgeworth is well known. In fact, it is well known beyond the realm of children's literature, as Miss Edgeworth had a long career as an author of novels and books of instruction. Her children's books contained no fairies, and her delicately didactic stories always had a moral. However, she was "the novelist of the nursery," and her characters were natural children and not abstractions. If the morals of her tales are forgotten, many of her accounts will be found to be good stories told in simple language, and in a natural manner.

The author of the "Dialogues on Entomology," who admired Miss Edgeworth and who imitated her method of instruction, apparently had a good knowledge of the entomology of the period, acquired from contemporary entomological literature or by study and personal observations, and perhaps by both. The book commences with some general statements about moths, caterpillars, insect eggs, transformations, etc., and finally goes into classification and the various orders of insects, with numerous interpolations referring to the habits, food plants, etc., of particular species, explanations of scientific names, little disquisitions about human nature, etc., ending with accounts of spiders and crabs, and of course, with a final statement about divine

Providence attending to the preservation of all his creatures, "even the most insignificant insect," and to the object of natural history in leading the mind from the works of God to God himself.

The dialogue method of imparting instruction is no longer popular, and in the past even entomology did not entirely escape the attention of the "question and answer" school of educators. In the book under discussion the information is imparted to the reader by means of forty-five conversations or dialogues between a little girl named Lucy and her highly informed mother. At this time some of these dialogues seem mildly amusing. Lucy asks most of the questions and her mother answers them. Samples of the dialogues are appended.

Page 26. *Lucy*: Do many sorts of caterpillars live in this way under the bark?

Mother: Several of our most beautiful and largest species.

Now, my love, I have promised your sister Fanny to answer her botanical questions; so we must defer the rest of the caterpillar history till tomorrow.

Lucy: Very well, mama; you have been very good to stay so long with me. I will now go and weed my nice bed of mignonette.

Page 129. *Lucy*: What a monstrous earwig there is under the crystal! I see, indeed, that it has a short elytra.

Mother: Try to describe it.

Lucy: Antennae, taper; elytra, short. Will you lend me your magnifying glass, that I may look at the feet?—Oh! I distinctly see three little joints in each foot. In the antennae, I think I can reckon fourteen joints; how very delicate they are. In the last place, the tail is forked.

Page 162. *Lucy*: Bugs are odious creatures; I am sure very little that is entertaining can be said of them; but so I thought of earwigs, and yet I was delighted with their history. Good-bye, mamma, I now go and dig up my bulbous roots.

Mother: Farewell, Lucy, I wish you success.

Page 215. *Lucy*: But mamma, only think of my cousin Louisa's saying last night that she thought all the accounts of insects must be fudge.

Mother: Your cousin Louisa is clever, and has read a great deal, for a girl of fourteen; but in such a desultory manner, that she has reaped but little advantage from what she has learned. Superficial knowledge usually produces vanity and self-sufficiency. . . . I have no doubt, that, as she grows older, she will cure herself of these defects.

Page 348. *Mother:* Today we shall proceed to the seventh and last order of insects; it comprehends all those that have no wings at any period of their lives; and as this is the distinguishing characteristic of the order, it is therefore called aptera, that is, without wings.

Lucy: But, mamma, in some of the other orders there are female insects which have no wings, the glow-worm, for instance.

Mother: True, Lucy; but no apterous insects, whether male or female, have wings; nor, with the exception of the flea, do they go through the transformations, which those in the other orders invariably observe. They are born in their complete shape, and only change their skins as they increase in size. There are several genera in this order, of which very little is known: I shall begin with a family, which, though always mentioned with well founded disgust, is, notwithstanding, deserving of some attention.

Lucy: I cannot imagine what creature you mean.

Mother: Indeed, it is most probably that my well combed and cleanly little girl never saw, much less felt, one of these odious little animals—I mean the *pediculus*, or louse, the scourge of filth and indolence.

Lucy: I have heard people mention a louse, but I never saw one.

Then mother tells Lucy how the common louse multiplies at a prodigious rate and how it sucks blood, but the dialogues soon discontinue such a “disgusting subject,” and Lucy and her mother proceed to the flea.

Twenty-five engravings illustrate the “Dialogues on Entomology,” but the insect drawings are stiff and formal. In some copies they have been hand colored.

I fear that very few Lucys grew up to be entomologists after having been fed on these “Dialogues.”

THE EARLIEST BUREAU OF ENTOMOLOGY

BY GAINES LIU

BIOLOGICAL LABORATORIES, HARVARD UNIVERSITY

My interest in the history of entomology in China goes back to 1931 when I was a student at Harvard. It was aroused rather accidentally. As a Chinese, when I read such a book as "A History of Applied Entomology" by Dr. L. O. Howard (Vol. 84, Smithsonian Miscellaneous Collections, 1930), naturally I was very eager to see what the author had to say about China. I was rather puzzled: indeed, I could hardly believe that China was not even mentioned in this book of more than 500 pages, although almost every country on earth was included. Does this omission mean that China has nothing worthwhile to be mentioned in the field of economic entomology, or that what China has is hidden behind her impenetrable language? Ever since then I followed the query as a hobby, and collected materials as they came along.

There is no question now that the Chinese language is the chief obstacle in this respect. This hobby study has led to quite a few startling revelations both in the field and from ancient literature. During the past seven years when I was travelling all over China, first as a Parker Fellow from Harvard University (1931-33) and later as a servant in the government service (1934-37), I have always kept it in mind to learn directly from Chinese farmers in the field what they know about insect control. In many cases I was really surprised to find how simple and ingenious some of their methods are.

Take the use of tobacco stubs and the firecrackers for instance. Among farmers along the Yangtze Valley and also in certain sections in both Fukien and Kwangsi, tobacco stubs are subjected to various means of treatment and used as a preventive against paddy borers. This sounds almost incredible at first blush when we learn that these stubs are planted alongside the rice seedlings several weeks after transplanting the rice. Yet it has been more or less confirmed at the National Agricultural Research Institute,

Nanking, that with the use of the stubs damage from these pyralids is not only reduced but production is also increased. On the other hand, no one has tested the effectiveness of the fire-crackers. These were used in certain sections of Kwangsi as a means of killing tree borers. The method of application is to fire these crackers in the tunnels and then seal the openings with mud. The explosion, the sealing and the fumes left behind must be, at least theoretically, very detrimental to the young larvæ.

The present day Chinese farmers have in store many valuable experiences for us to discover. But when we turn to the ancient Chinese literature, we frequently encounter surprises also. The citrus ants used as a means of checking homopterous pests in citrus orchards, a practice still continued today, was recorded as early as the 10th century in a book called "Ling Bio Lu Yi" by Liu Shen. The practice of cross breeding among the yellow and the white varieties of silkworm was described more or less in detail by Sung Ying Sing in 1637 in his "Tien Kun Kai Wu." Furthermore, probably nowhere in the world could we find today such a complete record of insect damage, particularly that caused by locusts, from the earliest known times down to the present as we will find in China.

All these, however, are still not so surprising. Dr. Howard stated in his book mentioned above that "Comparatively little attention was paid to insect damage in Europe until within the last one hundred years, and even during the early part of that period the damage to forests was the item particularly stressed" (page 1). If this were true and there is no doubt that it is, it is really astonishing to find in "Chow Li" under the section of Chu Kuan the records of a "Bureau of Entomology" with its various divisions, functions, personnels and methods of control so well organized that we could hardly believe it. Yet this book, "Chow Li," is one of the Chinese Classics and appeared long before the Christian era. Before we go any further, let us see what these divisions are. The following is a free translation of the original text.

1. Chien Shih—Division of Insect Borers.
 - a. Personnel—one head and two assistants.
 - b. Function—for the control of insect borers.

- c. Methods—fumigation with “mong ts’ao” (*Illicium anisatum* L.) or by means of “kung ying” (a form of propitiation).
2. Chi Bar Shih—Division of Household Pests.
 - a. Personnel—one head and two assistants.
 - b. Function—for control of household pests.
 - c. Methods—Spray with powder made from clam shells, charcoal and ashes.
3. Kou Shih—Division for Frog Control.
 - a. Personnel—one head and two assistants.
 - b. Function—for control of frogs.
 - c. Method—spray with ashes from “tu chu” (*Chrysanthemum*?). For stopping croaking and noises made by other aquatic animals, use smudging with this plant.
4. Hu Cho Shih—Division of Aquatic Vermin.
 - a. Personnel—one head and two assistants.
 - b. Function—for the control of aquatic vermin.
 - c. Method—Sinking with burning stone (lime?) or chasing with a drum made from “pao tu” (baked earth). To drive away the evil spirit, sink a cross made by piercing an elephant trunk through a board of “tu ku” (a kind of elm or *Ailanthus*).
5. Shue Shih—Division for Poisonous “ku” (internal vermin?).
 - a. Personnel—one head and two assistants.
 - b. Function—for control of “ku.”
 - c. Method—attack with the scented plants as used in “kun shui hui” (a form of propitiation). Compulsion necessary for community action.

There are divisions also for preying beasts, preying birds, forests, and even gramineous vegetation. But they are beyond our scope. Among the five divisions listed above, it is interesting to notice that whenever their actual methods of control fail, they invariably resort to the superstitious form of propitiation. It is also interesting to notice that some of the methods advocated here still persist as vestiges today. For instance, the painting of a wall with lime, charcoal and ashes is still common in the Huai Ho Valley. The use of “mong ts’ao” as a fumigant is also very common in south China.

On the other hand, it is rather difficult to identify the poisonous "ku." Evidence tends to show that it is some form of internal parasite because it is believed to enter the human body through the digestive tract. It is held responsible for some fatal diseases and, on account of its mysterious behavior, has assumed a magical nature in its present form, especially in Kwangsi, Yunnan and Kweichow. The contraction of this "ku" disease is generally believed to be through food or drink.

The "Chow Li," as mentioned above, is one of the 13 Chinese Classics. When it first appeared is almost impossible to determine today. According to popular belief, it came from the pen of Chow Kung, the best known prime minister of the Chow Dynasty, who lived about the later part of the 12th century before Christ. Incidentally, it may be mentioned that this Chow Kung is also popularly attributed to be the author of another Classic, namely "Erh Yah," where we have a catalogue of insects. This is a remarkable list as most of the included species are true insects. If one can give us such a catalogue, there is no doubt that he might be capable of conceiving the organization under discussion. But we are equally uncertain about the authorship of this "Erh Yah." However, it is certain that the book, "Chow Li," was produced before the Christian era. It was one of the books edited by Liu Shiang (77-6 B.C.).

Whether these various divisions had been actually put into practice is highly problematical. According to the opinion of some Chinese writers, the content of the whole book has never been put into practice. But even then, the conception of such ideas at such an early date is a wonder in itself.

THE ABUNDANCE OF TABANIDÆ AS REVEALED
BY ONE SEASON'S SURVEY AT
BABYLON, N. Y.¹

BY F. S. BLANTON

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As a student in medical entomology at Cornell University the writer became interested in insect-borne diseases and especially in the vectors of these diseases. This, together with his long interest in the Diptera, actuated him in making the observations recorded in this paper.

Since tularæmia, a widespread disease, has been transmitted by the bites of *Chrysops discalis*, it was thought that other, related flies would probably be able to transmit the disease.

The "Belmont Trail" and bridle path was chosen as an ideal spot for making these observations. The trail consists of a pedestrian's path running nearly parallel to the bridle path and both running along the side of a small stream. The stream, which is traversed by numerous bridges, is approximately four miles long as the crow flies. This stream serves as an outlet for Belmont Lake, which is located in the Belmont Lake State Park and empties into Argyle Lake and thence into the Great South Bay.

On week-ends and holidays enormous crowds visit the lake and numerous people use the trail and bridle path. The presence of great numbers of Tabanidæ, in addition to being annoying may become more serious should tularæmia get established in the native fauna along this trail. For that reason the writer thought it would be advisable to get as much information as possible on the species and the abundance of Tabanidæ in this vicinity.

The stream is rather swift in places, but there are side streams and old stream beds where the water moves very slowly. In many of these places the mud extends to the edge of the stream and sometimes for several feet into the grassy vegetation bordering the

¹ Acknowledgements are due L. L. Pechuman, of Cornell University, who assisted the writer with the identifications of the specimens, and Dr. Robert Matheson for reading the manuscript.

TABLE 1

A LIST OF THE SPECIES OF TABANIDÆ COLLECTED IN THE SURVEY AT
STATION No. 1

Species	Date collected		Peak of abundance	Total specimens collected
	From—	To—	Date	Number
<i>Chrysops celer</i> O.S.	June 29	.....	.....	1
<i>Chrysops delicatula</i> O.S.	" 22	July 14	.....	6
<i>Chrysops dimmocki</i> Hine	July 7	.....	.....	1
<i>Chrysops flavida</i> Wied.	June 23	July 24	June 28	31
<i>Chrysops geminata</i> Wied.	June 23	July 10	July 1	96
<i>Chrysops montana</i> O.S.	June 24	July 20	.....	7
<i>Chrysops pudica</i> O.S.	July 9	Aug. 5	.....	6
<i>Chrysops sackeni</i> Hine	June 24	July 9	.....	9
<i>Chrysops striata</i> O.S.	July 1	Aug. 16	.....	19
<i>Chrysops univittata</i> Macq.	June 22	Sept. 9	June 28	8,256
<i>Chrysops vittata</i> Wied.	June 28	Aug. 27	July 26	172
<i>Chrysops wiedemanni</i> Kröber	July 16	Aug. 19	.....	17
<i>Tabanus cinctus</i> F.	July 23	.....	.....	1
<i>Tabanus lasiophthalmus</i> Macq.	July 1	.....	.....	1
<i>Tabanus lincola</i> F.	July 9	.....	.....	1
<i>Tabanus nigrovittatus</i> Macq.	July 8	.....	.....	1
<i>Tabanus nivosus</i> O.S.	June 24	.....	.....	1
<i>Tabanus pumilus</i> Macq.	June 29	.....	.....	5
<i>Tabanus sparus</i> Whitn.	July 3	.....	.....	4
<i>Tabanus superjumentarius</i> Whitn.	July 20	.....	.....	1

stream. This affords an ideal breeding place for several species of Tabanidæ found in this vicinity.

A portion of the trail was chosen for making regular surveys, and this portion was designated as station No. 1. The distance covered by this station was approximately 1,200 yards, divided about equally between the pedestrian's path and the bridle path. Each survey lasted 15 minutes. The first survey was made on June 22 and the last one on September 16.

The conditions, including the date, hour, and weather, at the time of the survey were recorded. Since weather conditions apparently do not influence the emergence, these details are not given here.

The specimens were captured by swinging an insect net over the head in such a way that an almost complete figure 8 was described. Specimens of the predominating species, *Chrysops univittata*, were nearly all preserved in liquid but the others were

pinned. Since only the females of the Tabanidæ suck blood, only one male was captured. This was *Tabanus cinctus* F., which has been collected before on the bridle path in this same vicinity. It is found hovering from head height to 10 or 15 feet high.

At station No. 1 a total of 8,636 specimens of Tabanidæ was collected in a total of 38 surveys, of which 8,256 specimens belong to the one species *Chrysops univittata*.

On July 13 a survey was made at station No. 2, where specimens of 120 *Chrysops univittata* were captured in 15 minutes against 15 of all other tabanids caught. This station is adjacent to station 1. On July 24, surveys were made at stations 3 and 4, located on the southern part of the trail. Here the number of *univittata* was completely reversed. There were 4 against 44 of all other species at station 3, and 3 against 32 at station 4.

The species of Tabanidæ, along with such information as the dates for the first and last specimens collected, the peak of abundance, and the total collected are listed in Table 1.

The seasonal distribution of tabanids at station No. 1 is represented graphically by Figure 1.

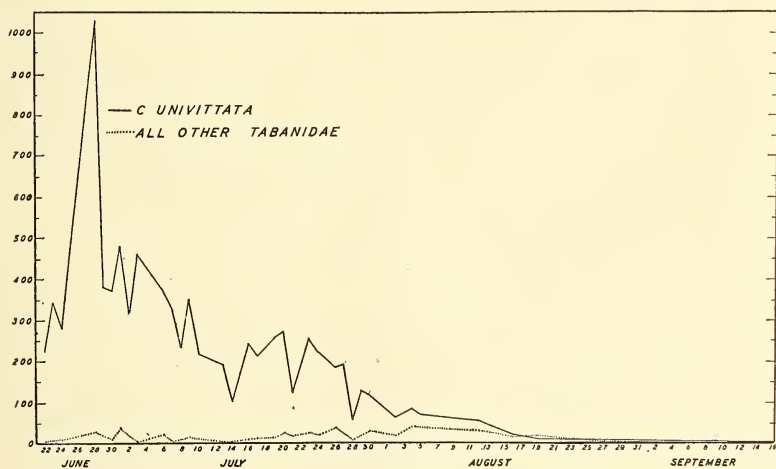


FIG. 1. The seasonal distribution of Tabanidæ at station 1, represented graphically.

MANTIS AND MOUSE

There is reproduced below a portion of a letter from Mrs. Mary Wymbs, of North Arlington, New Jersey, relating a most interesting observation:

" . . . On September 4, 1939, our dog was making such a fuss in our yard I went out to see what the trouble was and a praying mantis had a field mouse struggling desperately to release itself. The mouse was well grown—about two and one-half inches in length.

"The bug had its two front feet around the mouse's neck and its two rear feet on some phlox plants. The bug sucked the blood from the mouse's head until it died, proving the strength of the bug over the mouse. I called my husband and brother out to see what happened."

THE OLD WORLD MEMBRACIDÆ

BY FREDERIC W. GODING

(Continued from Vol. XLII, p. 480)

Tricentrus

Stål, *Analect. Hemip.* p. 387. (1866); *Taliopa* Buckton, *Tr. Linn. Soc. Lond. Zool.* ix, p. 334 (1905).

KEY TO SPECIES

- 1(8). Suprahumeral projecting forward, tips acute; pronotum brown, median carina usually percurrent weak or obsolete anteriorly, posterior process unicarinate.
- 2(7). Apex of posterior process passing apex of clavus, suprahumeral as long or longer than the intervening space; legs brown.
- 3(6). Suprahumeral twice as long as the intervening space, apex of posterior process just passing apex of clavus; tegmina smoky hyaline.
- 4(5). Suprahumeral slightly diverging almost parallel, obliquely inclined forward, tips recurved; tegmina with brown spot on apical angle; tarsi ferruginous; ocelli equidistant; long. excl. corn. 5.3, exp. corn. 3 mm. **acuticornis**
- 5(4). Suprahumeral strongly diverging, porrect, tips straight; apical margin of tegmina brownish; tarsi yellowish; ocelli nearer to the eyes; long. excl. corn. 4.5, exp. corn. 3 mm. **projectus**
- 6(3). Suprahumeral robust, strongly porrect, long as the intervening space, widely diverging, tips subacute; median carina of pronotum strong; posterior process heavy, gibba at base, dorsum arcuate, apex far passing apex of clavus; tegmina whitish opaque, veins nodulose; long. excl. corn. 4.5 mm. **paradoxus**
- 7(2). Apex of posterior process not passing apex of clavus, dorsum straight, tip black, suprahumeral slender, acute, slightly inclined forward, median carina of pronotum obsolete anteriorly; tegmina iridescent hyaline, costal veins near tips swollen and finely spined; tibiae and tarsi white; 5.3×3 mm **albipes**
- 8(1). Suprahumeral not projecting forward.
- 9(46). Suprahumeral horizontal or subhorizontal.
- 10(29). Apex of posterior process not passing the apex of clavus.
- 11(24). Posterior process unicarinate.
- 12(13). Suprahumeral almost as long as the intervening space, tips recurved, acute, posterior process slender; ferruginous, pubescent; tegmina hyaline, base piceous; 6-7 mm. **pallidus**

- 13(12). Length of suprahumeral not more than half width of intervening space.
- 14(19). Suprahumeral a fourth or less the width of the intervening space, median carina of pronotum percurrent.
- 15(18). Suprahumeral aborted, hardly a sixth the width of intervening space, posterior process straight gradually acuminate; black.
- 16(17). Shining, tawny pubescent; median carina of pronotum weak anteriorly, humeral conical, prismatic, apex of posterior process straight, not reaching apex of clavus; tegmina lurid, base black followed by white band; tarsi piceous; 5-6 mm. **finitimus**
- 17(16). Dull, sparsely pubescent; median carina of pronotum strongly percurrent, suprahumeral wider than high, not extended far as tips humeral, apex of posterior process elevated reaching apex of clavus, tarsi yellow; 4×1.7 , lat. int. hum. 2.2 mm. **brevicornis**
- 18(15). Suprahumeral distinct the length equal to a fourth the intervening space, posterior process sinuate, base depressed, swollen and depressed towards apex; entirely reddish brown, tegmina reddish hyaline; $4-6 \times 3.5-4.5$ mm. **fairmairei**
- 19(14). Length of suprahumeral equal to about half intervening space; pronotum brown, legs yellowish.
- 20(23). Tegmina smoky hyaline without darker markings.
- 21(22). Pronotum slightly pubescent, median carina weak anteriorly, apex of posterior process reaching (?) apex of clavus; 5-6 mm. **ferrugineus**
- 22(21). Pronotum distinctly yellow pubescent, median carina absent on metopidium, apex of posterior process much shorter than apex of clavus; veins of tegmina pubescent; 5-5.5 mm. **garampinus**
- 23(20). Tegmina subhyaline, brown and yellow clouded and spotted; pronotum yellow pubescent, no median carina on metopidium, apex of posterior process shorter than apex of clavus; 3-4.5 mm. **koshunensis**
- 24(11). Posterior process tricarinate, apex not passing apex of clavus; median carina percurrent.
- 25(26). Suprahumeral about as long as the intervening space; black, tarsi ochraceous; tegmina dark ochraceous, basal angular area black; $4-4.5 \times 3$ mm. **pronus**
- 26(25). Length of suprahumeral equal to a fourth the intervening space, broad, front margin strongly rounded, carina on upper surface behind middle.
- 27(28). Ferruginous the posterior apex black, pilose legs testaceous; tegmina pale bronze brown, base black; $4.5-5 \times 2.5-3$ mm. **gibbosulus**
- 28(27). Black, not pilose, legs brownish; tegmina pale ochraceous hyaline with a broad red basal fascia; 7×4 mm. **tinctoria**

- 29(10). Apex of posterior process passing apex of clavis, tricarinate.
- 30(33). Suprahumeral long as the intervening space; median carina of pronotum percurrent, apex of posterior process just passing apex of clavus.
- 31(32). Pronotum black, pilose, legs ochraceous; apex of posterior process elevated; tegmina subhyaline; basal area black; 5×3 mm. *euschistus*
- 32(31). Pronotum and legs testaceous, face, tips of suprahumeral and posterior process black, the latter straight; tegmina subhyaline, basal angle fuscous; 6×4 mm. *bovillus*
- 33(30). Suprahumeral not more than half as long as the intervening space.
- 34(45). Posterior process unicarinate.
- 35(38). Median carina absent on metopidium suprahumeral long as the intervening space, posterior process gradually acute apex just passing apex of clavus; legs brown.
- 36(37). Black, punctate, lightly pubescent, posterior process weakly arcuate; tegmina reddish hyaline, base black, apical margins fuscous; 6.5×4.6 mm. *capreolus*
- 37(36). Brown, shining, not punctate or pubescent; suprahumeral slender, tips black, posterior process straight, margins and decurved apex black; tegmina translucent hyaline, base brown; body black; 6.8×4 mm. *nitidus*
- 38(35). Median carina of pronotum percurrent, usually weak on metopidium.
- 39(44). Apex of posterior process just passing apex of clavus.
- 40(43). Suprahumeral half as long as the intervening space; punctate.
- 41(42). Piceous, legs tawny; suprahumeral and posterior process straight; tegmina lurid hyaline, base piceous; 5-6 mm. *femoratus*
- 42(41). Black, slightly pubescent, legs ferruginous; suprahumeral strongly recurved, apex of posterior process elevated; tegmina smoky hyaline, base black, outer margins narrowly ferruginous; 4.6×2.2 mm. *brevis*
- 43(40). Suprahumeral less than a fourth width of the intervening space; brown, shining, not punctate or pubescent; basal half of posterior process broad, apical half slender; tegmina smoky hyaline, base brown; 5.7×3.3 mm. *fulgidus*
- 44(39). Apex of posterior process strongly decurved reaching almost to tips of tegmina, basal half heavy, apical half abruptly slender; tips of suprahumeral and of humeral equal; pronotum brown, legs reddish, white granule at each knee; tegmina fuscohyaline, base opaque; 6×3 mm. *decurvatus*
- 45(34). Posterior process tricarinate, basal half heavy, apical half attenuate, suprahumeral about half as long as the intervening space, strongly recurved; pronotum black, median carina weakly

- percurrent, legs ferruginous; tegmina hyaline, base black; 5.2 × 3 mm. **papuænsis**
- 46(9). Suprahumeral more or less oblique.
- 47(70). Apex of posterior process not passing apex of clavus.
- 48(63). Posterior process unicarinate.
- 49(54). Suprahumeral as long or longer than the intervening space.
- 50(53). Apex of posterior process much shorter than apex of clavus; pronotum brown, median carina weakly percurrent.
- 51(52). Suprahumeral obliquely erect, tips recurved; not pilose; tegmina pale bronze hyaline, basal area fuscous brown; 5.5 × 3 mm. **bifurcus**
- 52(51). Suprahumeral moderately oblique, recurved; densely long pilose; tegmina yellowish hyaline, brown spot on middle of costa; 6 × 4 mm. **kuyanianus**
- 53(50). Apex of posterior process reaching apex of clavus, slender, suprahumeral substraight; pronotum pubescent; tegmina smoky hyaline, base brown, costal area pilose; 5 × 3 mm. **banguensis**
- 54(49). Suprahumeral not more than half as long as the intervening space, median carina of pronotum weakly percurrent.
- 55(58). Dorsum of posterior process lightly arcuate, suprahumeral weakly oblique; black, pubescent; ocelli equidistant.
- 56(57). Tegmina brown, translucent, base black, legs brown; 5.6 × 3.2 mm. **nigrofrontis**
- 57(56). Tegmina hyaline, base black, apical area smoky; tarsi fuscous; 4.5 × 2.7 mm. **pinguidorsis**
- 58(55). Dorsum of posterior process not arcuate.
- 59(62). Apex of posterior process straight, not elevated.
- 60(61). Brownish testaceous, pilose, paler posteriorly, legs ferruginous; suprahumeral short, not extended even with tips of humeral, strongly recurved; tegmina fusco-hyaline, base and tips narrowly brown; 4.5 × 1.9 mm. **attenuatus**
- 61(60). Black, not pilose, tarsi ferruginous; tegmina brown, base black; 5-6 mm. **caliginosus**
- 62(59). Posterior process robust, apex elevated, suprahumeral broad, front margin rounded, tips recurved, ridged on upper surface behind middle; black, pilose, legs piceous; tegmina dull brown hyaline, base black, large subbasal creamy white spot; 4 × 2.5 mm. **albomaculatus**
- 63(48). Posterior process tricarinate.
- 64(67). Suprahumeral about as long as the intervening space, strongly recurved, tips obtuse, median carina of pronotum percurrent; Tegmina with a pale transverse subbasal fascia.
- 65(66). Black, pilose, tarsi ochraceous; front margin of suprahumeral rounded, posterior process robust; tegmina pale bronze ochraceous, base black; 5 × 3 mm. **bicolor**

- 66(65). Brown, pilose, legs piceous; tegmina subhyaline, basal angular area brown; 7×3.5 mm. **repandus**
- 67(64). Suprahumeral not more than half as long as the intervening space.
- 68(69). Black, pubescent, legs yellowish; suprahumeral prismatic, curved, less than half the width between bases, tips recurved; tegmina yellowish hyaline, base narrowly black, veins hairy; 6 mm. **basalis**
- 69(68). Pronotum and legs testaceous; suprahumeral slender, tips black, apex of posterior process black not reaching apex of clavus; tegmina subhyaline, base narrowly ochraceous, veins sparingly granulose; 6×3 mm. **assamensis**
- 70(47). Apex of posterior process passing apex of clavus.
- 71(96). Posterior process unicarinate.
- 72(91). Suprahumeral as long or longer than the intervening space.
- 73(78). Apex of posterior process elevated, median carina of pronotum percurrent, suprahumeral strong; pubescent.
- 74(77). Pronotum brown, suprahumeral long as the intervening space; ocelli equidistant.
- 75(76). Long, narrow, bases of suprahumeral not widely separated; posterior process narrow; tegmina hyaline, base brown; legs ferruginous; 7.5×4 mm. **æquicornis**
- 76(75). Robust, suprahumeral widely separated at bases, acuminate, tips recurved, posterior process heavy, tip abruptly acute; tegmina smoky hyaline, base black, veins hairy; legs brown; 7×4.2 mm. ♀ **robustus**
- 77(74). Pronotum black, legs dark brown; ocelli nearer to eyes; suprahumeral one and one-half times longer than the intervening space, long, tips acute, decurved; posterior process lightly elevated at base and middle, apex passing far beyond apex of clavus; tegmina smoky hyaline, base black, outer margin black, veins with indistinct black nodules; 6.8×3.5 mm. **amurensis**
- 78(73). Apex of posterior process not lightly elevated.
- 79(88). Black, pubescent.
- 80(85). Median carina of pronotum percurrent usually weak anteriorly; posterior process straight; legs brown.
- 81(84). Suprahumeral weakly oblique, apex of posterior process straight.
- 82(83). Tegmina bronze hyaline, base black; suprahumeral ridged on upper surface, posterior process heavy; ocelli equidistant; 5.8×3.5 mm. **bakeri**
- 83(82). Tegmina gray vitreous, base black; suprahumeral long, acute, posterior process attenuated; 6-7 mm. **acer**
- 84(81). Suprahumeral almost erect, slender, recurved, apex of posterior process decurved; ocelli equidistant; tegmina, translucent bronze, base black, veins transparent near base; 6.7×4 mm. **panayensis**

- 85(80). Median carina absent on metopidium, front margin suprahumeral rounded, posterior process very narrow (possibly should be placed in *Tricentrodus*), sinuate; ocelli nearer to eyes; tegmina fuscohyaline, costal and apical margins clouded, two rows of hairs on veins; 6.5×3.7 mm. **pilinervosus**
- 86(79). Brown, pubescent, median carina of pronotum percurrent; ocelli equidistant.
- 87(90). Tegmina smoky hyaline; posterior process slender.
- 88(89). Pronotum and legs golden brown, suprahumeral slender, tips blunt, posterior process slender, straight, tip darker; base and tips of tegmina brown; 5.5×3.5 mm. **brunneus**
- 89(88). Pronotum dark brown, legs paler, suprahumeral heavy, tips acute, posterior process slender, tip decurved; base of tegmina narrowly black; 7.5×3.7 mm. **bergeri**
- 90(87). Tegmina dark brown, almost opaque, base black; (see 76, (75), ♀, but darker, suprahumeral shorter, and tip of posterior process straight); 6×3 mm. ♂ **robustus**
- 91(72). Suprahumeral about half as long as the intervening space; median carina of pronotum obsolete or absent on metopidium; ocelli equidistant.
- 92(93). Brown, pubescent, two dark basal spots, median carina absent on metopidium; humeral moderately prominent; suprahumeral normally situated, broad, tips rounded; posterior process heavy, dorsum arcuate, tip just passing apex of clavus; tegmina hyaline, base brown, tips pointed, veins indistinct; 4×2.8 mm. **altdorsus**
- 93(92). Black, median carina obsolete on metopidium; tegmina smoky hyaline, base black; legs yellowish.
- 94(95). Strongly pilose; suprahumeral slender, abnormally arising from extreme dorso-lateral margins of pronotum a central ridge on the upper surface; humeral large, auriculate; posterior process slender, depressed at middle; nodule at each knee; 7×4.8 mm. **plicatus**
- 95(94). Slightly pubescent; suprahumeral arising normally, humeral not prominent; posterior process straight; 5-6 mm. ♂ **congestus**
- 96(71). Posterior process tricarinate; pubescent or pilose.
- 97(128). Suprahumeral long as or longer than the intervening space.
- 98(105). Suprahumeral distinctly longer than width between bases, tips acute; median carina of pronotum percurrent; ocelli equidistant.
- 99(102). Apex of posterior process just passing apex or clavus, suprahumeral large, strongly recurved; tegmina sordid hyaline, base narrowly black.
- 100(101). Suprahumeral distinctly longer than the intervening space, posterior process slender, raised at base, depressed at middle;

- metopidium with two black spots, legs yellowish; corium with a brown apical spot; 6.6×3.7 mm. **curvicornis**
- 101(100). Suprahumeral broad, a little longer than width between their bases, posterior process straight, tip abruptly acute; legs ferruginous; 7×4 mm. **maacki**
- 102(99). Apex of posterior process passing far beyond apex of clavus, upper surface of suprahumeral ridged, tips recurved.
- 103(104). Dark brown, slender; suprahumeral slender, distinctly longer than width between their bases, posterior process slender, sinuate, tip decurved; tegmina sordid hyaline, base brown followed by a white band behind this a broad brown band; 7×4 mm. **fasciipennis**
- 104(103). Black, legs brown; suprahumeral strong, heavy, more than twice longer than width between their bases, posterior process slender, straight; tegmina bronze hyaline, base black, costal margin brown; 7.2×4.4 mm. **forticornis**
- 105(98). Suprahumeral equal in length to the intervening space.
- 106(113). Apex of posterior process just passing apex of clavus.
- 107(110). Brown or yellow, pubescent; ocelli equidistant; posterior process straight.
- 108(109). Castaneous; median carina of pronotum distinct, suprahumeral very heavy, broad, front margin rounded, upper surface ridged near hind margin, tips subacute, posterior process heavy, gradually acute, tip dark brown; tegmina brownish hyaline, base brown; 6.8×5 mm. **laticornis**
- 109(108). Dark yellow, two dark spots on base of metopidium; suprahumeral brown, recurved, posterior process slender, apical half brown; tegmina hyaline, base brown; 5.4×3 mm. **brunneicornis**
- 110(107). Black, legs ferruginous; suprahumeral recurved, tips acute, posterior process straight.
- 111(112). Tegmina smoky hyaline, base black, exterior apical veins pilose; tips of humeral blunt, median carina of pronotum obsolete on metopidium; ocelli equidistant; (is this the male of *congestus*?); 6.5×3.8 mm. **suluensis**
- 112(111). Tegmina hyaline, base broadly black, costal margin brown; median carina of pronotum weakly percurrent, tips of humeral acute; upper surface of suprahumeral ridged; ocelli nearer to the eyes; 4.6×3 mm. **albescens**
- 113(106). Apex of posterior process passing far beyond apex of clavus; ocelli equidistant; median carina of pronotum percurrent.
- 114(121). Brown, pubescent.
- 115(120). Apex of posterior process not curved upwardly.
- 116(119). Apex of posterior process straight, not decurved.
- 117(118). Abdomen brown, legs yellow, tip of posterior process blackish; tegmina hyaline, base narrowly brown; 7.2×5.2 mm. **manilænsis**

- 118(117). Abdomen black, legs brown; upper surface of suprahumeral ridged near hind edge; tegmina pale brownish hyaline, base brown; 7 mm. **divergens**
- 119(116). Apex of posterior process decurved, slender, suprahumeral slender, upper surface ridged; densely pubescent; legs ferruginous; tegmina hyaline, base brown; 6.8×4.2 mm. **pubescens**
- 120(115). Posterior process slender, curved upwardly, tip dark brown, upper surface of suprahumeral ridged; pronotum and legs ferruginous; tegmina fusco-hyaline, base ferruginous; 6.5×4.6 mm. **ferruginosus**
- 121(114). Black, pubescent; suprahumeral more or less recurved.
- 122(127). Apex of posterior process straight.
- 123(126). Posterior process slender; tegmina with two discoidal cells.
- 124(125). Ocelli epuidistant; suprahumeral strongly recurved; tegmina smoky hyaline, base black, veins hairy; legs black or brown; 6.6×4.6 mm. **spininervis**
- 125(124). Ocelli nearer to the eyes; suprahumeral slender, spinelike, upper surface centrally ridged, tips recurved; legs pale brown; 6×5 mm. **spinicornis**
- 126(123). Posterior process heavy, robust, gradually acute; legs ferruginous; tegmina hyaline, base black, three discoidal cells, tips fuscous on costal margin, costal veins strongly pilose; 5.2×3 mm. **spinidorsis**
- 127(122). Posterior process heavy, tip decurved; suprahumeral strong, broad, hind edge bicarinate; humeral large, auriculate; legs black; tegmina ferruginous hyaline, base black; 7×5 mm. **nigris**
- 128(97). Suprahumeral not longer than half the intervening space.
- 129(132). Posterior process straight, tip not passing apex of clavus, median carina pereurrent, suprahumeral weakly oblique, tips recurved.
- 130(131). Black, legs ochraceous; suprahumeral slender, apical area of posterior process brown; ocelli equidistant; tegmina hyaline, basal area black followed by a white transverse band; $5-6 \times 3$ mm. **allabens**
- 131(130). Ochraceous, anterior disk, front margins of suprahumeral and apex of posterior process with legs brown; suprahumeral broad, with posterior process robust; tegmina subhyaline, basal area brown enclosing an ochraceous spot; 6×3 mm. **resectus**
- 132(129). Posterior process weakly sinuate, apex passing far beyond apex of clavus, suprahumeral distinctly oblique; pronotum and legs brown.
- 133(134). Pronotum brown, sparingly pubescent, two smooth spots on metopidium, tips of suprahumeral and posterior process black

the latter gradually acute; tegmina vinaceous hyaline, iridescent, base black; ocelli nearer to the eyes; 5.4×3 mm.

nigroapicalis

- 134(133). Pronotum uniform golden brown, densely pubescent, supra-humerals very slender; tegmina smoky hyaline, base narrowly brown, exterior apical margin brownish; ocelli equidistant; 6×3.6 mm. **attenuicornis**

LIST OF SPECIES

- acuticornis** Funkhouser, Phil. Jour. Sci. xv, p. 22, figs. 5, 6. (1919). Panay, Culasi, Luzon, Philippines; Ft. de Kock, Sumatra.
- projectus** Distant, Faun. Brit. Ind. iv, p. 55, fig. 48. (1908). Tenasserim, Myitta, Calcutta, Tolly Ganj. India; Moulmein, Burma; Neuva Viscaya, Imugan, Luzon, Philippines.
- paradoxus** Lethierry, Ann. Soc. Ent. Belg. xix, p. 81, (page 5 in separata). (1876); Lindberg, Noc. Ent. iv, p. 23, figs. 1, 6. (1927). Spasskaja, Ussuri R. Vladivostok, Siberia.
- albipes** Funkhouser, Suppl. Ent. xv, p. 4, figs. 6, 7. (1927). Fort de Kock, Singapore, Sumatra.
- pallidus** Walker, List Hom. B. M. p. 625. (1851). Unknown.
- finitimus** Walker, List Hom. B. M. p. 628. (1851). Hongkong, China.
- brevicornis** Funkhouser, Jour. Sts. Br. Roy. Asiat. Soc. p. 214, figs. 7, 8. (1920). Sandakan, Borneo.
- fairmairei** Stål, Eug. Resa Omk. j. p. 284. (1859). Funkhouser, Biol. Memb. pl. 35, fig. 14. (1917). Phil. Jour. Sci. x, p. 367, figs. 1, 2. (1915). Lingn. Sci. Jour. vii, pl. 14, fig. 1. (1929). idem xv, p. 20, pl. 1, fig. 4. (1919). Los Baños, Rizal, Laguna, Montalban, Pæte, Panay, Culasi, Luzon, Philippines; South India; Malacca.
- sobrinus** Stål, Eug. Resa Omk. J p. 285. (1859). Java.
- ferrugineus** Walker, Jour. Linn. Soc. x, p. 187. (1868). New Guinea.
- garampinus** Matsumura, Annot. Zool. Jap. viii, p. 19. (1912). Koshun, Formosa.
- koshunensis** Matsumura, Annot. Zool. Jap. viii, p. 19. (1912). Shinsha, Koshun, Formosa.
- akonis** Matsumura, Annot. Zool. Jap. vii, p. 20. (1912). Ako, Koshun, Shinsha, Shirin, Hokuto, Formosa.
- pronus** Distant, Faun. Brit. Ind. vi, App. p. 166. (1916). Kavalai, Cochin State, India.
- gibbosulus** Walker, Ins. Saund. Hom. p. 80. (1858); Distant, Faun. Brit. Ind. iv, p. 54, fig. 46. (1908). Hindostan, India; Penang Is., Singapore, Sumatra; Kudat, Bettotan, Samawang, Borneo.
- flavipes** Melichar, Notes Leyden Mus. xxxvi, p. 112. (1914). Penang Is., Sumatra; Banjuwangi, Java.
- tinctoria** Buckton, Tr. Linn. Soc. Lond. Zool. ix, p. 334, pl. 22, fig. 4. (1905). Bangalore, India; Manila, Philippines. (?).

- fairmairei* Distant, Faun. Brit. Ind. iv, p. 58. (1908). Malacca; Philippines. (?).
- cuschistus* Distant, Faun. Brit. Ind. vi, App. p. 164. (1916). Tenasserim, Myitta, Bombay, India.
- bovillus* Distant, Faun. Brit. Ind. vi, App. p. 164. (1916). Moulmein, Burma.
- capreolus* Walker, List Hom. B. M. p. 627. (1851); Funkhouser, Biol. Memb. pl. 35, fig. 19. (1917); Phil. Jour. Sci. x, p. 386, pl. 2, fig. 10. (1915). Mt. Banahao, Laguna, Pæte, Darai, Luzon, Philippines.
- nitidus* Funkhouser, Suppl. Ent. xv, p. 2, figs. 1, 2. (1927). Ft. de Kock, Sumatra.
- femoratus* Walker, Jour. Linn. Soc. x, p. 186. (1868). Macassar, Patimurang, Loka, Wawokarang, Celebes.
- brevis* Funkhouser, Jour. N. Y. Ent. Soc. xxii, p. 239. (1914) Banguay Is., Kudat, Borneo; Barkuda Is., Chilka Lake, Ganjam, India.
- fulgidus* Funkhouser, Phil. Jour. Sci. xl, p. 122, pl. 2, figs. 19, 20. (1929). Pontianak, Borneo.
- decurvatus* Funkhouser, Jour. N. Y. Ent. Soc. xxii, p. 238, pl. 6, fig. 8. (1914). Dutch New Guinea.
- papuensis* Funkhouser, Phil. Jour. Sci. xl, p. 122, pl. 2, figs. 21, 22. (1929). Laloka, Papau, New Guinea.
- bifurcus* Distant, Faun. Brit. Ind. vi, App. p. 165, fig. 121. (1916). Darjiling, Behar, India.
- kuyanianus* Matsumura, Annot. Zool. Jap. viii, p. 19. (1912). Tappan. Horisha, Shako, Ako, Hashun, Formosa; Hokkaido, Honshu, Japan.
- banguensis* Funkhouser, Jour. N. Y. Ent. Soc. xxii, p. 238, pl. 6, fig. 9. (1914). Banguay Is., Kinabalu, Borneo; Perak, Sumatra.
- nigrofrontis* Funkhouser, Phil. Jour. Sci. xl, p. 125, pl. 2, figs. 27, 28. (1929). Penag Is., Sumatra.
- pinguidorsis* Funkhouser, Rec. Aust. Mus. xv, p. 308, pl. 26, figs. 9, 10. (1927). Broken Hill, N. S. W., Australia.
- attenuatus* Funkhouser, Phil. Jour. Sci. x, p. 388, pl. 2, fig. 13 (1915). Butuan, Panay, Culasi, Mindanao, Philippines.
- caliginosus* Walker, Jour. Linn. Soc. i, p. 93. (1856). Singapore, Anei Kloof, Sumatra; Biserat, Bali, Siam; Borneo.
- albomaculatus* Distant, Faun. Brit. Ind. iv, p. 56. (1908); Kershaw, Ann. Soc. Ent. Belg. lvii, pp. 191-201, figs. 1-13. (1914). Tenasserim, Myitta, Marikuppam, Assam, Garo Hills, Tura, India; Penang Is., Singapore, Sumatra.
- bicolor* Distant, Faun. Brit. Ind. iv, p. 55. (1908). Bombay, India.
- repandus* Distant, Faun. Brit. Ind. vi, App. p. 163. (1916). Assam, India; Panang Is., Sumatra; Sandakan, Borneo.
- basalis* Walker, List Hom. B. M. p. 626. (1851). Hongkong, China; Horisha, Ako, Shoka, Koshun, Formosa; Singapore, Sumatra; Colombo, Ceylon; Java.
- flavipes* Uhler, Proc. U. S. Nat. Mus. xix, p. 284. (1896). Japan.

- assamensis* Distant, Faun. Brit. Ind. iv, p. 57. (1908). Assam, Margherita, Teppakulam, India; Penang Is., Singapore, Sumatra.
- æquicornis* Funkhouser, Phil. Jour. Sci. xxxiii, p. 116, pl. 4, figs. 19, 20. (1927). Benguet, Luzon, Philippines.
- robustus* Funkhouser, (♂), Phil. Jour. Sci. xiii, p. 26, pl. 1, figs. 3, 4. (1918). Benguet, Bagnio, Nueva Viscaya, Imugan, Panay, Tibiao, Culasi, Flores, Luzon, Philippines.
- amurensis* Lindberg, Noc. Ent. iv, p. 26, figs. 4, 9. (1927). Amur R., Nokolajevsk, Siberia.
- bakeri* Funkhouser, Phil. Jour. Sci. xl, p. 119, pl. 1, fig. 13, pl. 2, fig. 14. (1929). Sandakan, Bettotan, Borneo.
- acer* Walker, List Hom. B. M. Suppl. p. 163. (1858). Malacca.
- panayensis* Funkhouser, Phil. Jour. Sci. xxxiii, p. 114, pl. 3, figs. 13, 14. (1927). Panay, Philippines.
- pilinervosus* Funkhouser, Jour. Ent. Zool. vi, p. 68, fig. 2. (1914); Biol. Memb. pl. 35, fig. 18. (1917). Los Baños, Philippines; Banguey Is., Borneo.
- brunneus* Funkhouser, Jour. Sts. Br. Roy. Asiat. Soc. p. 7. (1918). Singapore, Penang Is., Sumatra; Sandakan, Borneo.
- bergeri* Funkhouser, Ann. Zool. Mus. Acad. Sci. USSR. xxviii, p. 151, pl. 6, fig. 7. (1927). Zolotoj Rog, Vladivostok, Siberia.
- robutus* Funkhouser, (♀), Phil. Jour. Sci. xiii, p. 26. (1918). Philippines.
- altidorsus* Funkhouser, Phil. Jour. Sci. xl, p. 124, pl. 2, figs. 25, 26. (1929). Penang, Sumatra.
- plicatus* Funkhouser, Phil. Jour. Sci. x, p. 387, pl. 2, fig. 12. (1915). Dapitan, Mindanao, Philippines; Banguey Is., Borneo.
- congestus* Walker, Jour. Linn. Soc. x, p. 187. (1868). Sulu Is., Philippines.
- curvicornis* Funkhouser, Ann. Zool. Mus. Acad. Sci. USSR. xxviii, p. 153, pl. 6, fig. 9. (1927). Hwang-ho R., Ordos, Mongolia, China.
- maacki* Funkhouser, Ann. Zool. Mus. Acad. Sci. USSR. xxviii, p. 152, pl. 6, fig. 8. (1927). Amur R., Siberia.
- fasciipennis* Funkhouser, Phil. Jour. Sci. xiii, p. 28, pl. 1, figs. 7, 8. (1918). Nueva Viscaya, Imugan, Luzon, Philippines.
- forticornis* Funkhouser, Phil. Jour. Sci. xl, p. 118, pl. 1, fig. 11, pl. 2, fig. 12. (1929). Imugan, Nueva Viscaya, Luzon, Philippines.
- laticornis* Funkhouser, Phil. Jour. Sci. xiii, p. 27, pl. 1, figs. 5, 6. (1918). Imugan, Nueva Viscaya, Luzon, Philippines.
- brunneicornis* Funkhouser, Phil. Jour. Sci. xl, p. 126, pl. 2, figs. 31, 32. (1929). Philippines.
- suluensis* Funkhouser, Phil. Jour. Sci. xl, p. 125, pl. 2, figs. 29, 30. (1929). Tawitawa, Sulu Is., Philippines.
- albescens* Funkhouser, Phil. Jour. Sci. xl, p. 121, pl. 1, fig. 17, pl. 2, fig. 18. (1929). Sandakan, Borneo; Penang Is., Sumatra.
- allabens* Funkhouser, Jour. Sts. Br. Roy. Asiat. Soc. p. 210. (1920). Penang Is., Sumatra; Sandakan, Bettotan, Borneo.

- manilensis* Funkhouser, Phil. Jour. Sci. xxxiii, p. 115, pl. 3, figs. 17, 18. (1927). Manila, Luzon, Philippines.
- divergens* Bierman, Notes Leyden Mus. xxxiii, p. 44. (1911). Banjuwangi, Semarang, Nongkodjadjar, Java.
- pubescens* Funkhouser, Phil. Jour. Sci. xl, p. 127, pl. 2, figs. 33, 34. (1929). Catbalogan, Samar, Philippines.
- ferruginosus* Funkhouser, Phil. Jour. Sci. xl, p. 123, pl. 2, figs. 23, 24. (1929). Penang Is., Sumatra.
- spininervis* Funkhouser, Phil. Jour. Sci. xxxiii, p. 115, pl. 3, figs. 15, 16. (1927). Samar Is., Philippines.
- spiniornis* Funkhouser, Jour. Sts. Br. Roy. Asiat. Soc. p. 6. (1918). Penang Is., Ft. de Kock, Singapore, Sumatra.
- spiniorsis* Funkhouser, Jour. Fed. Malay Sts. Mus. xiv, p. 475, figs. 7, 8. (1929). Kudat, Borneo.
- nigris* Funkhouser, Jour. Sts. Br. Roy. Asiat. Soc. p. 212, figs. 5, 6. (1920). Sandakan, Borneo.
- allabens* Distant, Faun. Brit. Ind. vi, App. p. 166, fig. 122. (1916). Perak Is., Penang Is., Sumatra; Kurseong, E. Himalayas, Darjiling, India; Taiping, China; Sandakan, Bettotan, Borneo.
- resectus* Distant, Faun. Brit. Ind. vi, App. p. 167. (1916). Maymyo, Burma; Myitta, Tenerassam, India; Penang Is., Singapore, Perak, Sumatra; Sandakan, Borneo.
- nigroapicalis* Funkhouser, Suppl. Ent. xv, p. 3, figs. 4, 5. (1927). Ft. de Kock, Sumatra.
- attenuicornis* Funkhouser, Phil. Jour. Sci. xl, p. 120, pl. 1, fig. 15, pl. 2, fig. 16. (1929). Sandakan, Borneo.

Tricentroides

Distant, Faun. Brit. Ind. vi, App. p. 169. (1916).

KEY TO SPECIES

- 1(2). Brown, head and base of metopidium broadly black, legs pale ochraceous; tegmina subhyaline, base and costal are blackish; suprahumerals slender, oblique, slightly longer than intervening space, tips black, posterior process straight, apical area curving upwardly black; 7×4.5 mm. **proprius**
- 2(1). Sordid green, doubtless testaceous with age, tegmina brownish subhyaline, apical area broadly ochraceous; suprahumerals short, moderately strong, posterior process arcuate, apex straight; 5×3 mm **orcus**

LIST OF SPECIES

- proprius** Distant, Faun. Brit. Ind. vi, App. p. 169, fig. 124. (1916). Cherrapunji, Assam, India.
- orcus** Buckton, Mon. Memb. p. 247, pl. 60, fig. 7. (1903). Philippines.

Maguva

Melichar, Homop. Ceylon, p. 109. (1903). *Anchonoides* Distant, Faun. Brit. Ind. vi, App. p. 162. (1916).

KEY TO SPECIES

- 1(2). Posterior process substraight from basal angle, apical area distant from margins of tegmina, lobe beneath with a posterior spur; suprahumeral twice longer than broad, tips recurved; pronotum and legs brown; tegmina ferruginous, costal margin broadly darker; 9×7 mm. **horrida**
- 2(1). Posterior process strongly sinuate from basal angle, apical area impinging upon margins of tegmina, lobe beneath not spurred, suprahumeral four times longer than broad, curved outwardly, tips recurved; pronotum brown, legs yellowish; 9×6.5 mm. **typica**

LIST OF SPECIES

- horrida** Melichar, Homop. Ceylon, p. 109, pl. 2, fig. 21. (1903); Distant, Faun. Brit. Ind. iv, p. 14, fig. 10 (1908). Ceylon.
- typica** Distant, Faun. Brit. Ind. vi, App. p. 162, fig. 120. (1916). Hakgala, Ceylon.

Anchon

Buckton, Mon. Memb. p. 214. (1903).

KEY TO SPECIES

- 1(4). Basal angle of posterior process dentate anteriorly.
- 2(3). Posterior process arched beyond basal angle, suprahumeral slender, much longer than the intervening space; entirely black, tegmina ferruginous; 6×4 mm. **remigium**
- 3(2). Posterior process straight beyond basal angle, suprahumeral robust, long as the intermediate space; pronotum fuscous brown, legs yellowish; tegmina hyaline or subopaque, two brown spots on apical margin; 5×3 mm. **rectangulatum**
- 4(1). Basal angle of posterior process not dentate anteriorly.
- 5(12). Posterior process straight or substraight beyond basal angle.
- 6(11). Apex of posterior process passing far beyond apex of clavus; brown.
- 7(10). Suprahumeral robust, twice longer than the intervening space, margins serrate; densely pilose.
- 8(9). Suprahumeral straight, posterior process brownish ochraceous, spinulose, tip black, legs yellowish; tegmina brown, base paler, brown spot beyond clavus; 6×3.5 mm. **echinatum**
- 9(8). Suprahumeral strongly outwardly curved, posterior process concolorous, legs ferruginous; tegmina clear hyaline, shining, bases fuscous red; 6×4 mm. **bucktoni**

- 10(7). Suprahumeral slender, long as the intervening space, curved outwardly, margins not serrate, legs brown; tegmina clear hyaline, base and spots on tip of costa, at apical angle, and behind clavus brown; 6×4 mm. **dirce**
- 11(6). Apex of posterior process much shorter than apex of clavus, slightly convex, suprahumeral weakly oblique, long as the intermediate space; black, legs ochraceous; tegmina subhyaline, spot beyond clavus and apical angle brown; 5×3.5 mm. **brevis**
- 12(5). Posterior process lightly but distinctly sinuate beyond basal angle, apex blackish, suprahumeral curved outwardly, long.
- 13(14). Pronotum brownish testaceous, densely pilose, basal angle of posterior process rounded, legs concolorous; tegmina semiopaque gray, spot beyond clavus and at apical angle brown; 5×3.5 mm. **pilosum**
- 14(13). Pronotum umber brown, pubescent, basal angle acute, legs pale testaceous; tegmina brown, apical area hyaline, brown spot beyond clavus; 6×3.5 mm. **ulniforme**

LIST OF SPECIES

- remigium** Buckton, Mon. Memb. p. 215, pl. 48, fig. 5. (1903). Unknown.
- rectangulatum** Kirby, Jour. Linn. Soc. Zool. xxiv, p. 166. (1891); Distant Faun. Brit. Ind. iv, p. 51, fig. 43. (1908). Anuradhapura, Ceylon; Mysore, India. Semarang, Wonosobo, Salatiga, Java.
- pilosus** Melichar, Hom. Faun. Ceylon, p. 119, pl. 6, fig. 11. (1903). Peradeniya, Ceylon.
- echinatum** Distant, Faun. Brit. Ind. iv, p. 51, fig. 42. (1908). Tenasserim, Myitta, India.
- bucktoni** nom. nov.
- rectangulatum** Buckton, Mon. Memb. p. 215, pl. 48, fig. 3. (1903), preoccupied. Ceylon.
- dirce** Buckton, Mon. Memb. p. 216, pl. 49, fig. 2 (1903). Distant, Faun. Brit. Ind. iv, p. 52, fig. 44. (1908). Kandy, Ceylon.
- brevis** Distant, Faun. Brit. Ind. iv, p. 53, fig. 45. (1908). Anuradhapura, Ceylon.
- pilosum** Walker, List Hom. B. M. p. 606. (1851); Distant, Faun. Brit. Ind. iv, p. 49, fig. 40 (1908). Bombay, Mysore, Pusa, Behar, Coimbatore, Shevaroy Hills, Anam, India; Peradeniya, Ceylon; Kumaon, Japan; Formosa.
- ulniforme** Buckton, Mon. Memb. p. 216, pl. 49, fig. 1. (1903); Distant, Faun. Brit. Ind. iv, p. 50, fig. 41. (1908). Tenasserim, Myitta, Mysore, India. Semarang, Wonosobo, Java.

Centrotus

- Fabricius, Syst. Rhyng. p. 18. (1803); *Beaufortiana* Distant, Ann. Mag. N. H. xviii, p. 30, (1916).

KEY TO SPECIES

- 1(6). Suprahumeral directed obliquely forward, tips dilated, truncate, posterior process tricarinate, base well separated from scutellum.
- 2(5). Pronotum piceous or black, granulose, tegmina black or piceous small pale spot near apex of clavus.
- 3(4). Suprahumeral three times longer than the intervening space, posterior process nearly straight, apex passing far beyond apex of clavus; tegmina piceous; 8×7 mm. *ramosus*
- 4(3). Suprahumeral twice longer than the intervening space, posterior process arcuate, apex just passing apex of clavus; tegmina black, veins pilose; $8 \times 5.5-6$ mm. *granulatus*
- 5(2). Pronotum ferruginous, densely punctuate, not granulose, posterior process sinuate, apex just passing apex of clavus; tegmina ferruginous; 5 mm. *angustulus*
- 6(1). Suprahumeral transverse, horizontal or oblique, not directed forward.
- 7(12). Suprahumeral oblique.
- 8(11). Suprahumeral about as long as the intervening space, apex of posterior process passing far beyond apex of clavus.
- 9(10). Pronotum purplish black, coarsely nodulate, two white spots on base, legs brown; tips of suprahumeral truncate, posterior process straight, slightly raised above the scutellum; tegmina brown, inner area hyaline; 9×6 mm. *biculatus*
- 10(9). Pronotum coarsely punctuate, not nodulate, brown to black, legs brown; tips of suprahumeral acute, posterior process sinuate, distinctly raised above the scutellum; tegmina vinaceous hyaline to brown or brown spot near apex of clavus and at tips; 10×4 mm. (variable) *cornutus*
- 11(8). Suprahumeral much longer than the intermediate space, slightly diverging, posterior process straight; pronotum black, legs tawny; tegmina yellow hyaline, base and costal area black; 8 mm. *albigutta*
- 12(7). Suprahumeral horizontal or subhorizontal, about as long as the intervening space, tips truncate or subtruncate; more or less tuberculate.
- 13(20). Base of posterior process but slightly separated from the scutellum, suprahumeral slightly elevated above the horizontal.
- 14(19). Posterior process straight.
- 15(18). Suprahumeral long as the intervening space, tips subtruncate; pronotum black or purplish.
- 16(17). Black, metopidium and legs purplish, tegmina purplish brown; 8.5×5 mm. *metangensis*
- 17(16). Entirely black; 10 mm. *albilatus*
- 18(15). Suprahumeral shorter than the intervening space, tips roundly truncate; pronotum piceous, tubercles and median carina black, legs and tegmina dark brown; 8×4 mm. *talumensis*

- 19(14). Posterior process sinuate, suprahumeral bicarinate on upper and lower surfaces, the larger granules between the keels, tips truncate; tegmina ferruginous, pubescent, legs dark brown; 6-7 mm. *indicatus*
- 20(13). Base of posterior process distinctly separated from the scutellum, suprahumeral horizontal, not at all elevated, bicarinate on the upper surface, tips broadly truncate; tegmina dark brown; pronotum black, legs ochraceous; 10 × 8 mm. *transversus*

LIST OF SPECIES

- ramosus* Distant, Faun. Brit. Ind. iv, p. 47, fig. 39. (1908). Udagama, Ceylon.
- granulatus* Kirby, Jour. Linn. Soc. Zool. xxiv, p. 166. (1891); Buckton Mon. Memb. p. 226, pl. 50, fig. 2. (1903). Kandy, Pundaloya, Nalanda, Patipolla, Ceylon.
- angustulus* Melichar, Hom. Ceylon, p. 112. (1903). Pundaloya, Ceylon.
- bioculatus* Kirby, Jour. Linn. Soc. Zool. xxiv, p. 166. (1891); Distant, Faun. Brit. Ind. iv, p. 47, fig. 38. (1908). Maskeliya, Haputale, Pundaloya, Newera Ellya, Ceylon.
- cornutus* Linnæus, Fauna Suec. p. 879. (1746); DeGeer, Mem. Ins. iii, p. 181, pl. 11, fig. 22. (1773); Petagna, Ins. Ent. p. 617, pl. 9, fig. 2. (1792); Tigny, Hist. Nat. Ins. iv, p. 120, pl. 5, fig. 3. (1802); Blanchard, Hemip. p. 182, fig. 8. (1840); Edwards, Hem. Hom. Brit. IIs, p. 19, pl. 3, fig. 2. (1896); Kirby, Nat. Hist. p. 601, fig. 94. (1897); Melichar, Vest. Klubu. Pirod. iv, p. 14, pl. 1, fig. 2. (1902); Buckton, Mon. Memb. p. 244-5, 266, pl. 56, fig. 7. (1903); Jensen-Haarup, Handb. Dan. N. H. p. 68, fig. 37. (1920). All over Europe, and Asia.
- nervosus* Motschoulsky, Bul. Soc. Imp. Nat. Mosc. xxiv, pp. 648-57. (1851).
- italicus* Kirschbaum, Cicad. p. 67. (1855).
- turcicus* Kirschbaum, Cicad. p. 67. (1855).
- abbreviatus* Kirschbaum, Cicad. p. 67. (1855).
- siculus* Kirschbaum, Cicad. p. 66. (1855).
- gallicus* Kirschbaum, Cicad. p. 67. (1855).
- horncicade* Taschenberg, Beld. Ind. Libr. p. 541. (1861).
- depressus* Fieber, Rev. Mag. Zool. iii, p. 15. (1876).
- obtus* Fieber, Rev. Mag. Zool. iii, p. 19. (1876).
- rugosus* Buckton, Mon. Memb. p. 243, pl. 56, fig. 3. (1903).
- albigutta* Walker, Jour. Linn. Soc. x, p. 184. (1868). New Guinea.
- metangensis* Distant, Ann. Mag. N. H. xvii, p. 323. (1916). Mt. Matang, Borneo.
- albilatus* Walker, Jour. Linn. Soc. x, p. 184. (1868). New Guinea.
- talumensis* Distant, Ann. Mag. N. H. xviii, p. 292. (1916). Talum, Siamese Malay States.

indicatus Melichar, Hom. Ceylon, p. 111. (1903). Kandy, Badulla, Rathapura Moruwale, Jaffna, Gamaduwa, Patipolla, Weligama, Madulsima, Uva, Ceylon; Chikkaballapura, S. India.

transversus Distant, Faun. Brit. Ind. iv, p. 48. (1908). Margherita, Assam, India.

Platybelus

Stål, Hemip. Afric. iv, p. 96. (1866).

KEY TO SPECIES

One small yellow species, suprahumeral long, oblique, posterior process slender, long as abdomen, apex decurved fuscous; median carina percurrent; tegmina clear hyaline; 5.5×3 mm. **luteus**

LIST OF SPECIES

luteus Funkhouser, Jour. N. Y. Ent. Soc. xxii, p. 239. (1914). Banguey, Borneo.

Evanchon

Goding, Jour. N. Y. Ent. Soc. xxxviii, p. 40. (1930; *Anchonoides* Funkhouser, part; *Maguva* Funkhouser, part.

KEY TO SPECIES

- 1(4). Dark brown; suprahumeral short, robust, bases not distant, tips blunt, posterior process about as long as the abdomen.
- 2(3). Tegmina entirely coriaceous, opaque, base black, central area mottled brown and black, tips brown; ocelli equidistant; suprahumeral long as wide at bases, horizontal, base swollen, tips abruptly acuminate; apex of scutellum bidentate; 6×2.8 mm. **sordidus**
- 3(2). Tegmina with base brown, opaque, then smoky hyaline, then clear hyaline, apical area amber hyaline; ocelli nearer to eyes; pronotum with five white pubescent longitudinal lines; suprahumeral weakly oblique, about as long as wide at bases, middle area elevated above and nodulate, tips obliquely truncate hind angle acute; apex of scutellum truncate; tarsi flavous; 5×4 mm. **variegatus**
- 4(1). Black; suprahumeral distant between bases, moderately long, slender, acute; posterior process distinctly longer than abdomen.
- 5(6). Pronotum shining, not pubescent, legs dark brown; ocelli nearer to eyes; suprahumeral long as intervening space, oblique, tips lightly decurved; posterior process with a conical node at base; tegmina black with three hyaline areas, and three discoidal cells; 6×4 mm. **nigra**
- 6(5). Pronotum with five white longitudinal pubescent stripes; suprahumeral half as long as the intervening space, horizontal, base without dorsal node; tegmina with bases black, apical two-thirds hyaline, interior angle and apical margin brown, stigma

black, two discoidal cells; abdomen black and white, legs black middle and hind tibiae and base of tarsi luteus; 6×4 mm.

serpentinus

LIST OF SPECIES

- sordidus** Funkhouser, Jour. Roy. Asiat. Soc. vi, p. 13. (1928). Siberut Is., Sumatra.
variegatus Funkhouser, Jour. Str. Br. Roy. Asiat. Soc. No. 79, p. 4. (1918). Singapore.
nigra Funkhouser, Phil. Jour. Sci. Br. Roy. Asiat. Soc. No. 82, p. 209, figs. 3 and 4. (1920). Sandakan, Borneo.
Serpentinus Funkhouser, Jour. Str. Br. Roy. Asiat. Soc. No. 82, p. 209, figs. 3, 4. (1920). Sandakan, Borneo.

Uroxiphini

Pogontypus

- Distant, Faun. Brit. Ind. iv, p. 67. (1908).

KEY TO SPECIES

- 1(6). Pronotum tricarinate anteriorly, posterior process close to the scutellum; tegmina yellowish, base and costal margins broadly piceous.
 2(5). Posterior process tricarinate.
 3(4). Base of head highly arched with a tubercle above each ocellus a circular depression between, black; ocelli some nearer to and even with the upper margin of the large prominent eyes. Pronotum gibbous, finely punctate, dark ferruginous, base broadly and smooth spot above each eye black, the basal margin a strong carina; median carina strongly percurrent, lateral carinae short, curved, nearer to humerals than to median carina; posterior process paler, abruptly depressed and narrow from the extreme base, straight, impinging upon the scutellum and margins of tegmina to apex of clavus, tip blunt. Tegmina yellow hyaline, base broadly piceous the hyaline area extended through the middle, costal cell dark ferruginous and with base punctuate; two contiguous discoidal cells and five apical cells their veins curved inwardly; clavus with two veins, exterior vein curved to inner margin behind middle, apex obtuse; wings with four apical cells. Body and femora black, tibiae and tarsi pale ferruginous, chest yellow pubescent. Type, female, long. 4, lat. 1.3 mm. From Tamworth, N. S. W., Australia. (*Lea*). **australis** new species
 4(3). Base of head not bituberculate, ocelli as in *australis*; pronotum dark brown to black, lateral carinae midway between humerals and percurrent median carina, posterior process lightly sinuate, not depressed at base, median spot and tip black in brown examples, tip passing apex of clavus; tegmina rust yellow, base and broad costal margin darker; legs rust yellow; 4 mm. **complicatus**

- 5(2). Posterior process tricarinate, grayish white, middle and apex purplish, passing apex of clavus; pronotum ochraceous, rugulose; tegmina purplish, subapical spot and apical margin grayish white; chest purplish brown, abdomen and legs ochraceous, margins of abdominal segments purplish brown; 4 mm. **horvathi**
- 6(1). Pronotum unicarinate, testaceous, body concolorous; posterior process stramineous, sinuate, slightly separated from scutellum, median spot and tip fuscous reaching apex of clavus; tegmina ochraceous, apical margin paler with two large fuscous spots; legs yellowish, tips of tarsi black; 4 × 2 mm. **dissimilis**

LIST OF SPECIES

australis Goding, supra. Tamworth, N. S. W., Australia.

complicatus Melichar, Hom. Ceylon, p. 125. (1903); Distant, Faun. Brit. Ind. iv, p. 67, fig. 55. (1908). Negombo, Pattipola, Kandy, Yatiyantola, Ceylon.

horvathi Distant, Faun. Brit. Ind. iv, p. 67. (1908). Yatiyantola, Ceylon.

dissimilis Distant, Faun. Brit. Ind. vi, App. p. 173, fig. 127. (1916). Ceylon.

Melicharella

Goding, Jour. N. Y. Ent. Soc. xxxviii, p. 39. (1930); *Machærotypus* Melichar, Homop. Ceylon, p. 125. (1903).

KEY TO SPECIES

- 1(4). Posterior process tricarinate, tip just passing apex of clavus; tegmina yellow subhyaline; legs ochraceous.
- 2(3). Pronotum piceous to black, pubescent, median carina percurrent; basal and costal areas of tegmina brown, veins to fourth and fifth apical cells curved inwardly, sometimes brown spot behind clavus; 4.7–5 mm. (*?Popontypus*) **inculta**
- 3(2). Pronotum ochraceous, coarsely granulate, median carina absent anteriorly; basal and costal areas ochraceous, apical veins straight, brown spot behind clavus; 4.5–5 mm. **pallescens**
- 4(1). Posterior process unicarinate, apex black not reaching apex of clavus; front of pronotum and humerals black, disk and posterior process with legs ochraceous; median carina percurrent; basal and costal areas black; 5 mm. **nuwarana**

LIST OF SPECIES

inculta Melichar, Hom. Ceylon, p. 124. (1903); Distant, Faun. Brit. Ind. iv. p. 68, fig. 56. (1908). Pattipola, Ceylon.

discretus Melichar, Hom. Ceylon, p. 125. (1903). Nuwara Eliya, Peradeniya, Ceylon.

pallescens Distant, Faun. Brit. Ind. vi, App. p. 173. (1916). Nuwara Eliya, Ceylon.

nuwarana Distant, Faun. Brit. Ind. vi, App. p. 174. (1916). Nuwara Eliya, Ceylon.

Occator

Distant, Faun. Brit. Ind. vi, App. p. 174. (1916).

KEY TO SPECIES

One black species, tibiae yellowish, posterior process slender, apical half obliquely elevated even with apex of clavus; tegmina shining ochraceous, base and most of costal margin black; 5 mm. **erectus**

LIST OF SPECIES

erectus Distant, Faun. Brit. Ind. vi, App. p. 174, fig. 128. (1916) Kur-seong, E. Himalayas, India.

Demanga

Distant, Faun. Brit. Ind. iv, p. 69. (1908).

KEY TO SPECIES

- 1(2). Black, densely pilose, legs brown; median carina of pronotum per-current, posterior process obliquely straight, tricarinate, apex touching margins of tegmina far beyond apex of clavus; tegmina bronze subhyaline, base brown; 8×3 mm. **sooknana**
- 2(1). Brown, densely pubescent; median carina of pronotum nearly obsolete, posterior process unicarinate, sinuate, entirely distant from margins of tegmina, much shorter than clavus; tegmina ferruginous hyaline, base narrowly brown, tips clouded; 10×4 mm. **brunnea**

LIST OF SPECIES

sooknana Distant, Faun. Brit. Ind. iv, p. 69, fig. 57. (1908). Sookna, India.

brunnea Funkhouser, Rec. Ind. Mus. xxiv, p. 328, pl. 10, fig. 5. (1922). Mungpoo, Darjiling, E. Himalayas, India.

Narnia

Walker, Jour. Linn. Soc. x, p. 192. (1868). *Terentius* Stål, Bid. Memb. K. p. 286. (1869).

KEY TO SPECIES

- 1(8). Black or piceous.
- 2(5). Median carina absent on the metopidium; pronotum black.
- 3(4). Tegmina dark fuscous, base black; legs reddish; 7×3 mm. **densa**
- 4(3). Tegmina cinereous, base black, legs tawny; 7 mm. **retracta**
- 5(2). Median carina of pronotum percurrent, faint on metopidium.
- 6(7). Piceous, abdomen and legs yellowish piceous; apex of posterior process decurved; tegmina vitreous, costa and tips pale piceous; 8×4 mm. **convexa**
- 7(6). Black, legs piceous; apex of posterior process straight; tegmina

- shining, ochraceous, apical area castaneous brown, base, costal area and narrow apical margin black; 8×4 mm. **rolandi**
 8(1). Tawny; streak each side of base and one each side on slender area of posterior process, broad basal band on abdomen, and legs pale yellow; tegmina pellucid, base tawny; median carina absent on metopidium; 6 mm. **rostrata**

LIST OF SPECIES

- densa** Walker, Jour. Linn. Soc. x, p. 189. (1868). New Guinea.
punctatissimus Stål, Bid. Memb. K. p. 286. (1869). New Guinea; Batehian Is; Dory Is. (both near New Guinea).
spissus and *pictipennis* Distant, Ann. Mag. N. H. xvi, p. 493. (1915). nom. nud.
retracta Walker, Jour. Linn. Soc. x, p. 190. (1868). Morty Is., East Indies.
convexa Stål, Bid. Memb. K. p. 286. (1869); Goding, Mon. Aust. Memb. p. 7, pl. 1, figs. 8, 14. (1903). Rockhampton, Brisbane, Cairns, Queensland; Tweed R., N. S. W.; Williamstown, South Australia.
rolandi Distant, Ann. Mag. N. H. xvi, p. 492. (1915). Binituri R., New Guinea; Kurandi, Queensland, Australia.
rostrata Walker, Jour. Linn. Soc. x, p. 192. (1868). Flores Is., S. of Celebes Is.

Dingkana

Goding, Mon. Aust. Memb. p. 8, (1903).

KEY TO SPECIES

- 1(8). Tegmina entirely or partly brown, base brown or black; unicarinate.
 2(7). Tegmina partly brown and partly hyaline.
 3(6). Apical area or margin brown, base black.
 4(5). Base of tegmina broadly black, apical two-thirds translucent brown, broad decolored vitreous central band between, radial and ulnar veins nodulate; pronotum black, coarsely punctate, posterior process tectifor, gradually acuminate, strongly decurved from base, unicarinate not extended on metopidium, long as abdomen; head black, punctate, wider than long, base sinuate, ocelli nearer to and even with center of eyes, margins of genæ slightly sinuate; legs and abdomen dark brown dorsum of the latter piceous, tarsi reddish; 6×2 mm. **vitrefascia** new species.

Described from two females from Dutch New Guinea, in collection of Goding.

- 5(4). Tegmina cinerous hyaline, tips dark brown, abdomen and legs black, tarsi reddish; median carina of pronotum weakly percurrent, posterior process straight; 5 mm. **curtula**
 6(3). Tegmina cinerous hyaline, oblique basal area piceous, two irregular incomplete brown bands; piceous, legs ferruginous; median carina weakly percurrent, posterior process decurved; 7 mm. **nubifascia**

- 7(2). Tegmina unicolorous brown, base black; black, thickly pubescent, legs reddish, median carina weakly pereurrent, posterior process straight; 6 mm. **densa**
- 8(1). Tegmina vinaceous hyaline without brown markings; black, apex of posterior process decurved, unicarinate.
- 9(10). Median carina of pronotum weakly pereurrent, posterior process slightly curved; legs black; 5 mm. **contermina**
- 10(9). Median carina absent on metopidium, posterior process strongly curved from base; brown, legs yellowish; 5×2 mm. **borealis**

LIST OF SPECIES

vitreifascia Goding, supra. Dutch New Guinea.

curtula Walker, Jour. Linn. Soc. x, p. 190. (1868). Mysol Is., near New Guinea.

nubifascia Walker, Jour. Linn. Soc. x, p. 191. (1868). New Guinea.

densa Walker, Jour. Linn. Soc. x, p. 189. (1868). New Guinea.

contermina Walker, (♀), Jour. Linn. Soc. x, p. 190. (1868). Aru Is., near New Guinea.

reductus Walker, (♂), Jour. Linn. Soc. x, p. 190 (1868). New Guinea.

borealis Goding, Mon. Aust. Memb. p. 9, fig. 1, fig. 21. (1903). Cairns, Queensland, Australia.

*Leptocentrina***Maarbarus**

Distant, Faun. Brit. Ind. iv, p. 16. (1908).

KEY TO SPECIES

- 1(2). Suprahumeral oblique, straight, inclined backwardly, slender, tips acute; pronotum brown, posterior process extended to tips of tegmina, the latter brown; 7×3 mm. **cinctus**
- 2(1). Suprahumeral oblique, strongly recurved, tips acute and carinate; pronotum black, median carina pereurrent, posterior process tricarinate, shorter than the tegmina; tegmina pale yellow, base, costal area and spot near clavus black; legs yellowish; 6.6×5 mm. **bubalus**

LIST OF SPECIES

cinctus Buckton, Mon. Memb. p. 236, pl. 53, fig. 8. (1903). Calcutta, India.

bubalus Kirby, Jour. Linn. Soc. Zool. xxiv, p. 167. (1891); Distant, Faun. Brit. Ind. iv, p. 17, fig. 13. (1908). Pundaluoya, Maskeliya, Ceylon.

Bathoutha

Distant, Faun. Brit. Ind. iv, p. 23. (1908).

KEY TO SPECIES

One brown species, median carina weak on metopidium, suprahumeral

porrect tips truncate, the outer angle a horizontal spine, finely tuberculate above; posterior process strongly arcuate from base, slender, tricarinate; tegmina piceous, bronze brown on inner and costal apical areas; legs ochraceous; 7.5×4 mm. **indicans**

LIST OF SPECIES

indicans Walker, List Hom. B. M. Suppl. p. 128 (1858); Distant, Faun. Brit. Ind. iv. p. 23, fig. 21. (1908). Yatiyantota, Ceylon.

Indicopleustes

Distant, Faun. Brit. Ind. iv, p. 25. (1908).

KEY TO SPECIES

1(2). Suprahumeral oblique, sides parallel, tips truncate, posterior process slender, tricarinate, strongly convexly elevated from base, apical half impinging upon margins of tegmina; pronotum dark brown, not crested, median carina absent on metopidium; tegmina brown, opaque, sometimes with small white spots; $4-5.5 \times 2.5-3$ mm. **curvatus**

2(1). Suprahumeral horizontal, gradually acuminate; posterior process robust, base straight and near base of scutellum, middle convexly elevated, apical half sinuous on margins of tegmina; pronotum black, median carina percurrent and crested on disk; tegmina dark brown, opaque, apical third pale yellow hyaline; 5.5 mm. **apicatus**

LIST OF SPECIES

curvatus Melichar, Hom. Ceylon, p. 112. (1903). Peradeniya, Kandy, Ceylon.

albomaculatus Distant, Faun. Brit. Ind. iv, p. 25, fig. 23. (1908). Peradeniya, Ceylon.

apicatus Melichar, Notes Leyden Mus. xxxvi, p. 113, fig. 7. (1914). Nusa Kambangan, Java.

Parapogon

Distant, Faun. Brit. Ind. iv, p. 22. (1908).

KEY TO SPECIES

1(2). Suprahumeral horizontal, posterior process robustly convex at base, then obliquely straight, unicarinate, castaneous; pronotum black, legs testaceous; tegmina subhyaline, broad basal area, costal and subcostal areas on basal two-thirds, and spot near clavus piceous, whole inner area bronze, tips hyaline; 4×2 mm. **kandyiana**

2(1). Suprahumeral moderately oblique, posterior process strong, but slightly elevated above the scutellum, straight, tricarinate, apical third slender; pronotum and legs brownish ochraceous; tegmina pale ochraceous, broad central longitudinal to apical margin beyond

clavus and large costal apical spot shining stramineous; 5.5-7 × 4 mm. **insignis**

LIST OF SPECIES

kandyiana Distant, Faun. Brit. Ind. iv, p. 22, fig. 20 (1908). Kandy, Ceylon.

insignis Distant, Faun. Brit. Ind. vi, App. p. 153, fig. 110. (1916). Nuwara Eliya, Ceylon.

Leptocentrus

Stål, Berlin Ent. Zeit. x, p. 386. (1866); *Rabduchus* Buckton, Mon. Memb. p. 251. (1903); *Bocchar* Jacobi, Sjost, Kil-Meru Exped. p. 120. (1910), part.

KEY TO SPECIES

- 1(14). Posterior process distant from the scutellum and margins of tegmina from base to apex.
- 2(11). Suprahumeral more or less strongly oblique.
- 3(6). Suprahumeral about as long as the intervening space, moderately oblique, posterior process distinctly convexly elevated at base then straight, tricarinate usually, median carina percurrent; tegmina brownish.
- 4(5). Dark brown, shining, apex of posterior process not extended beyond apex of clavus; tegmina very long, narrow, brownish subhyaline; 10 × 5 mm. **impunctus**
- 5(4). Black, lengthy pilose, apex of posterior process extended slightly beyond apex of clavus; tegmina pale bronze; 6-6.5 × 4-4.5 mm. **bajulans**
- 6(3). Suprahumeral much longer than the intervening space, strongly oblique, apex of posterior process extending far beyond apex of clavus; brown.
- 7(10). Posterior straight from base not convex at its origin, suprahumeral long, slender, strongly recurved.
- 8(9). Reddish brown, densely pubescent, median carina percurrent; suprahumeral three times longer than the intervening space, a small tooth between bases, posterior process straight, apex slightly decurved; tegmina smoky hyaline; 8 × 6 mm. **tenuicornis**
- 9(8). Brown, slightly pilose, metopidium shining, the median carina obsolete; suprahumeral more than twice longer than the space between bases, posterior process subarcuate from base, apex black; tegmina hyaline, brown apical spot; 9 × 7 mm. **gracilis**
- 10(7). Fusco-ferruginous, densely yellow pubescent; suprahumeral longer than the intervening space, moderately oblique, posterior process convexly elevated at base, median carina not extended on metopidium; tegmina pale fuscous hyaline; 9 × 5 mm. **antelope**
- 11(2). Suprahumeral horizontal or subhorizontal, strongly recurved, apex of posterior process extended far beyond apex of clavus, median carina percurrent; pronotum black.

- 12(13). Suprahumeral broad, more than twice longer than the intervening space; tegmina pale lurid; 8×7 mm. **taurifrons**
- 13(12). Suprahumeral short, obliquely narrowed, tips acute carinate; tegmina pale bronze ochraceous, costal area black; 7×5 mm. **obortus**
- 14(1). Posterior process distant from the scutellum, apex touching margins of tegmina.
- 15(30). Suprahumeral distinctly longer sometimes strongly oblique.
- 16(23). Suprahumeral a little longer than the intervening space, moderately oblique, strongly recurved, posterior process subareuate, tricarinate, median carina percurrent, apex extended far beyond apex of clavus.
- 17(20). Scutellum long as broad at base; pronotum black.
- 18(19). Pronotum pubescent; tegmina smoky hyaline base and tarsi brown; 8×6 mm. **arcuatus**
- 19(18). Pronotum not pubescent; tegmina shining bronze; 5×3 mm. **ustus**
- 20(17). Scutellum distinctly longer than broad at base.
- 21(22). Entirely deep purple, shining, not pubescent, scutellum twice longer than broad, purple; tegmina bronze hyaline, base black, veins purple, three discoidal cells; 7.5×5 mm. **purpureus**
- 22(21). Entirely black, pubescent, scutellum some longer than broad base densely white tomentose, tarsi brown; tegmina smoky hyaline, base narrowly brown, two discoidal cells; 8×6 mm. **jacobsoni**
- 23(16). Suprahumeral more than twice longer than the intervening space, strongly recurved, carina near hind margin of upper surface, posterior process tricarinate base convexly elevated; base and costal area of tegmina black or brown.
- 24(29). Pronotum black.
- 25(28). Posterior process concolorous, median carina percurrent; base and costal area of tegmina black; scutellum about long as broad.
- 26(27). Pronotum not pubescent, apical fourth of posterior process impinging upon margins of tegmina; tarsi piceous or yellowish; tegmina shining ochraceous; $7-9 \times 4.5-7$ mm. **leucaspis**
- 27(26). Pronotum longly pilose, tip of posterior process touching margins of tegmina; tarsi black; tegmina pale ochraceous subhyaline; 9×9 mm. **longispinus**
- 28(25). Posterior process distinctly reddish; pronotum pubescent, abdomen and legs brown; scutellum wider than long; tegmina fuscous hyaline, base broadly yellowish, costal margin brown; 8.6×6.8 mm. **rufospinus**
- 29(24). Fuscous brown, pilose, no median carina on metopidium; suprahumeral obliquely erect, tips subtruncate front angle rounded; scutellum long as wide; tegmina pale bronze, extreme base and costal margin fuscous brown; 8×6 mm. **abdullah**
- 30(15). Suprahumeral horizontal or subhorizontal, posterior process tricarinate.

- 31(40). Suprahumeral distinctly longer than the intervening space.
- 32(37). Pronotum black, median carina percurrent; ocelli equidistant.
- 33(36). Posterior process substraight from base; pilose.
- 34(35). Suprahumeral twice longer than width between bases, tips slightly depressed; scutellum longer than wide; tegmina smoky hyaline, extreme base and apical spot brown; 8×7 mm. **manilensis**
- 35(34). Suprahumeral a little longer than space between bases, broad, front margin subfoliaceous, tips abruptly acute; scutellum long as broad; tegmina pale lurid, costal margin black; $8 \times 6.5-7$ mm. **reponens**
- 36(33). Posterior process abruptly convexly elevated at base then substraight, suprahumeral robust some longer than intervening space, carina near hind margin of upper surface, tips acute; tegmina pale bronze ochraceous, base and apical half of costal margin black; $7-8 \times 5-6$ mm. **taurus**
- 37(32). Pronotum not black, strongly pubescent.
- 38(39). Ferruginous, posterior process black, legs tawny, median carina percurrent; suprahumeral moderately long, slender; tegmina vitreous; base tawny; 6×4 mm. **obliquus**
- 39(38). Reddish testaceous; suprahumeral a little longer than space between bases, robust, apical area acuminate; posterior process arcuate from base to apex median carina not extended on the metopidium; base of exterior discoidal cell of tegmina petiolate; 7.5×5 mm. **subflavus**
- 40(31). Suprahumeral not longer than the intervening space, usually shorter; median carina of pronotum percurrent.
- 41(46). Pronotum black.
- 42(45). Tegmina bronze or lurid hyaline.
- 43(44). Base and costal margin of tegmina black or brown; apex of posterior process extended far beyond apex of clavus; $6-7 \times 3.5-4$ mm. **vicarius**
- 44(43). Base and margins of tegmina black with a large subbasal white spot; apex of posterior process just passing apex of clavus; 6.5×3.5 mm. **albonotatus**
- 45(42). Tegmina black, tips colorless hyaline; apex of posterior process extended far beyond apex of clavus; 8×4 mm. **substitutus**
- 46(41). Pronotum not black.
- 47(50). Pronotum dark brown, densely pubescent.
- 48(49). Densely yellow pubescent; suprahumeral shorter than space between bases, tips acute, posterior process curved at base, long as clavus; scutellum long as wide; tegmina pale bronze, base apical half of costa piceous, two discoidal cells; $8 \times 4-4.5$ mm. **orientalis**
- 49(48). Entirely covered with dense snow-white tomentum, legs yellow; basal margin of pronotum projecting forward, suprahumeral about equal in length to width between bases, broad, acute;

- dorsum arcuate from base of metopidium to posterior apex the latter just passing apex of clavus; scutellum twice longer than broad; tegmina smoky hyaline, base and costal area black, three discoidal cells; 6.5×3.6 mm. **alba**
- 50(47). Pronotum purplish brown, apex of scutellum greenish, body and legs ochraceous; ocelli nearer to the eyes; suprahumeral shorter than width between bases, posterior process sinuate, apex depressed just passing apex of clavus; tegmina pale bronze brown; $9-10 \times 4.5$ mm. **scutellatus**

LIST OF SPECIES

- impunctus** Buckton, Tr. Linn. Soc. Zool. ix, p. 334, pl. 22, fig. 6. (1905).
Padaukbin, Burma, India.
- bajulans** Distant, Faun. Brit. Ind. vi, App. p. 155, fig. 113. (1916).
Bengal, Calcutta, Murshidabad, Berhampur, Chittagong, Rangamati, Travancore, Kulattupuzha, India; Chalahudi, Cochin State; Moulmein, Burma.
- tenuicornis** Funkhouser, Suppl. Ent. xv, p. 11, figs. 18, 19. (1927).
Lubek Sulasin, Sumatra.
- gracilis** Funkhouser, Rec. Aust. Mus. xv, p. 307, pl. 26, figs. 7, 8. (1927).
Broken Hill, N. S. W., Australia.
- antilope** Stål, Eug. Resa Omk. J. Zool. iv, p. 284. (1859).
Manila, Philippines.
- taurifrons** Walker, List Hom. B. M. p. 608. (1851).
Java.
- obortus** Distant, Faun. Brit. Ind. vi, App. p. 154. (1916).
Moulmein Burma; Simla Hills, Phagu, Assam, Garo Hills, Tura, Madras, Ganjam, Barkuda Is., Chilka Lake, India.
- arcuatus** Funkhouser, Phil. Jour. Sci. xxxiii, p. 113, pl. 3, figs. 11, 12. (1927).
Palawan, Philippines.
- ustus** Buckton, Mon. Memb. p. 236, pl. 53, fig. 7. (1903).
Ceylon; Madras, India.
- purpureus** Funkhouser, Jour. Fed. Malay Sts. Mus. xiv, p. 471, figs. 3, 4. (1929).
Bettotan, Borneo.
- jacobsoni** Funkhouser, Suppl. Ent. xv, p. 12, figs. 20-22. (1927).
Ft. de Kock, Harau Kloof, Talang, Sumatra.
- leucaspis** Walker, List Hom. B. M. Suppl. p. 158. (1858); Buckton, Mon. Memb. p. 235, pl. 53, fig. 3. (1903); Distant, Faun. Brit. Ind. iv, p. 30, fig. 25, (1908).
Chatrapur, Dum Dum, Taiping, Punjab, Rawalpindi, India; Kandy, Pundaluoya, Maskeliya, Peradeniya, Ceylon; Perak, Singapore, Sumatra; Sandaken, Kudat, Borneo; Batbatan Is., Philippines.
- tauris** Walker, List Hom. B. M. p. 602. (1851).
India.
- flexicorne** Walker, Ins. Saund. Hom. p. 79. (1858).
India.
- atrocoxis** Kirby, Jour. Linn. Soc. Zool. xxiv, p. 164. (1894).
Nawalapitya, Ceylon.
- mephistopheles** Buckton, Mon. Memb. p. 235, pl. 53, fig. 4. (1903).
Sikhim, India.

- longispinus** Distant, Faun. Brit. Ind. iv, p. 31. (1908). Burma; Mormugao, Portugues India; Penang Is., Singapore, Sumatra; Sandakan, Borneo; Semarang, Java.
- rufospinus** Funkhouser, Suppl. Ent. xv, p. 13, figs. 23-25. (1927). Ft. de Kock, Sumatra; Sumbawa, Java.
- abdullah** Distant, Ann. Mag. N. H. xviii, p. 290. (1916). Bulsit Besar, Siamese Malay States; Mt. Maropok, Dent, Borneo.
- manilænsis** Funkhouser, Phil. Jour. Sci. xxxiii, p. 112, pl. 2, figs. 9, 10. (1927). Manila, Philippines.
- responens** Walker, List Hom. B. M. p. 604. (1851); Funkhouser, Phil. Jour. Sci. x, p. 379, pl. 1, fig. 6. (1915). Tenerassim, Bengal, Myitta, India; Ceylon; Sumatra; Los Baños, Manila, Luzon, Davao, Montalban, Pæte, Panay, Tibiao, Culasi, Lipati, Mindanco, Philippines.
- taurus** Fabricius, Syst. Ent. p. 676. (1775); Distant, Faun. Brit. Ind. iv, p. 28, fig. 24. (1908). Common throughout India; Moulmein, Burma; Rura, Garo Hill, India; Cambodge, Siam; Singapore, Sumatra; Timor Is.; Kinabalu, Borneo; Philippines.
- rupricapra** Fabricius, Ent. Syst. iv, p. 14. (1798). India.
- scutellaris** Fabricius, Syst. Rhyng. p. 19. (1803). India.
- tricornis** Hardwick, Jour. Zool. xiii, p. 114, pl. 30, figs. c, d. (1828). India.
- terminalis** Walker, List Hom. B. M. p. 605. (1851). Hong Kong, China.
- gazella** Buckton, Mon. Memb. p. 235, pl. 53, fig. 5. (1903). Ceylon.
- obliquus** Walker, Ins. Saund. Hom. p. 79. (1858). Hindostan, India.
- subflavus** Noulhier and Martin, Hemip. Mission Pavie, Indo-China, iii, p. 167, pl. 10, fig. 5. (1904). Cambodge, Siam.
- vicarius** Walker, List Hom. B. M. p. 605. (1851). Java.
- insignis** Distant, Faun. Brit. Ind. iv, p. 32. (1908). Muching, Borneo; Nankauri, Nicobar Is.
- albonotatus** Distant, Ann. Mag. N. H. xviii, p. 289. (1916). Nilgiri Hills, India.
- substitutus** Walker, List Hom. B. M. p. 605. (1851). N. Bengal, Calcutta, Bombay, Mysore, Rajmanal, Bhogaon, Purneah, Orissa, Gopkuda Is. Chilka Lake, India; Peradeniya, Elephant Pass, Colombo, Yatiyantota, Balangoda, Kelani Valley, Ceylon.
- orientalis** Schumacher, Suppl. Ent. iv, p. 116. (1915). Formosa Is., Japan.
- alba** Funkhouser, Jour. Fed. Malay Sts. Mus. xiv, p. 470, figs. 1, 2. (1929). Bettotan, Borneo.
- scutellatus** Distant, Faun. Brit. Ind. vi, App. p. 155, fig. 112. (1916). Kodaikanal, India.

Nilautama

- Distant, Faun. Brit. Ind. iv, p. 32. (1908).

KEY TO SPECIES

- 1(4). Posterior process very short not passing apex of scutellum, tricarinate, suprahumeral short about as long as posterior process, robust, weakly oblique; pronotum black, pubescent, legs brown.
- 2(3). Posterior process horizontal, apex slightly upraised, blunt, tips of suprahumeral recurved, blunt; tegmina smoky hyaline, base white, costal margin, and abdomen brown, tarsi yellow; 7×4 mm. *minutispina*
- 3(2). Posterior process obliquely elevated almost erect, apex acute, suprahumeral recurved from base, apical area abruptly acute; tegmina yellow clouded without darker markings; abdomen black; 7 mm. *tricornis*
- 4(1). Posterior process longer reaching apex of clavus; pronotum black, base and costal margins of tegmina broadly black.
- 5(6). Suprahumeral oblique, broad, sides parallel, carinate behind middle above, tips roundly truncate, recurved, posterior process tricarinate, moderately elevated, tip acute; tegmina bronze hyaline, abdomen black, legs brown; 7×4.5 mm. *typica*
- 6(5). "Black, dull, scabrous. Abdomen tawny towards base above. Legs tawny. Wings hyaline, slightly grayish; veins black; fore wings black at base and along the costa. Length of body $1\frac{3}{4}$ lines; of the (expanded) wings 4 lines." (Type mutilated, suprahumeral and posterior process broken off. Distant) *cicadiformis*

LIST OF SPECIES

- minutisuina* Funkhouser, Jour. Str. Br. Roy. Asiat. Soc. p. 3. (1918). Penang Is., Sumatra.
- tricornis* Melichar, Notes Leyden Mus. xxxvi, p. 114, fig. 8. (1914). Verlaten Eiland, Krakatau Is., near Sumatra.
- typica* Distant, Faun. Brit. Ind. iv, p. 32, fig. 26. (1908) Tenasserin, Myitta, India.
- cicadiformis* Walker, Jour. Linn. Soc. i, p. 164. (1857). Sarawak, Borneo.

Arimanes

- Distant, Ann. Mag. N. H. xviii, p. 290. (1916).

KEY TO SPECIES

- 1(2). Posterior process extended to tips of tegmina; suprahumeral brown, long, tips clavate and truncate; tegmina pale bronze brown, radial and costal cells granulose; piceous, legs ochraceous; tip of suprahumeral to tips of tegmina 9 mm. *doryensis*
- 2(1). Posterior process shorter than the abdomen, suprahumeral compressed, tips obtuse, recurved; tegmina hyaline, base and tips brown; fuscous brown, legs ferruginous, knees paler; 6 mm. *magellani*

LIST OF SPECIES

doryensis Distant, Ann. Mag. N. H. xviii, p. 290. (1916). Dory, New Guinea.

magellani Fairmaire, Rev. Memb. p. 513. (1846). Manila, Philippines.

Telingana

Distant, Faun. Brit. Ind. iv, p. 17. (1908).

KEY TO SPECIES

- 1(20). Suprahumerals more or less oblique, posterior process tricarinate median carina percurrent, apex extended far beyond apex of clavus; black, rarely brown.
- 2(19). Suprahumerals about as long as the space between bases; costal area of tegmina broadly black or brown.
- 3(10). Tegmina vinaceous hyaline, apical margin more or less black or brown.
- 4(9). Tegmina broad, a little longer than the abdomen, exterior half black or brown not reaching tips; scutellum distinctly longer than broad at base.
- 5(8). Posterior process strongly convexly elevated at base and distant from the scutellum then oblique to apex which touches or closely approaches margins of tegmina; pronotum black.
- 6(7). Posterior process brown, tips of suprahumerals recurved; tegmina shining, inner apical margin black; legs fuscous yellow; 6.5×3 mm. **cognata**
- 7(6). Posterior process concolorous black, suprahumerals strongly recurved; apical margin of tegmina dark brown; legs fuscous, tarsi ochraceous; 6×3.5 mm. **travancorensis**
- 8(5). Posterior process substraight from base then horizontal and sinuate, narrowly separated from scutellum and margins of tegmina; pronotum bronze black, posterior process and legs pale brown; apex of scutellum rounded slightly notched; tegmina blackish, large inner apical area and larger inner area stramineous; 7.5–8×4 mm. **balteata**
- 9(4). Tegmina narrow, apical third extended beyond tip of abdomen, yellow hyaline, costa ferruginous, first discoidal and second apical cell fuscous; scutellum about as long as broad; pronotum shining black, rugose, apical third of suprahumerals recurved, posterior process convex at base then oblique; 9.5×5.5 mm. **scutellata**
- 10(3). Tegmina vinaceous hyaline, apical margin concolorous; suprahumerals weakly oblique, posterior process convexly elevated at base.
- 11(18). Veins of tegmina smooth, not granulose.
- 12(17). Pronotum punctate, not granulate.
- 13(16). Tegmina pale yellow hyaline; pronotum black.
- 14(15). Suprahumerals substraight; costa black, hind tibiae and tarsi whitish; 7 mm. **varipes**

- 15(14). Suprahumeral strongly recurved; broad costal area black; legs rufo-testaceous, middle and hind pairs paler; 6×3 mm. *decipiens*
- 16(13). Tegmina pale castaneous; tips of suprahumeral recurved; legs ochraceous, tips of tibiae and tarsi piceous; 6.5×5 mm. *flavipes*
- 17(12). Pronotum black or brown, granulose, middle and hind tibiae ochraceous; posterior process moderately curved at base, almost long as tegmina, the latter bronze yellow, base of clavus black; $8-9 \times 6$ mm. *canescens*
- 18(11). Tegmina yellow subhyaline, veins granulose, costal margin brown, pronotum black, legs yellowish brown; 8.5×6 mm. *formosana*
- 19(2). Suprahumeral more than twice longer than the intermediate space, strongly oblique, curved outwardly, posterior process arcuate from base to apex distant its entire length from the scutellum and margins of tegmina; pronotum piceous black, middle and hind legs ochraceous; tegmina bronze, costal area and inner margin beyond clavus piceous; $8-10.5 \times 5.5-6$ mm. *capistrata*
- 20(1). Suprahumeral horizontal or subhorizontal, posterior process tricarinate median carina percurrent, apex extended far beyond apex of clavus; black, rarely dark brown.
- 21(30). Costal margins of tegmina broadly black.
- 22(25). Apical margins of tegmina narrowly black or brown, tips of suprahumeral recurved.
- 23(24). Pronotum rugulose; tegmina pale bronze, apical margin brown; 8×6 mm. *recurvata*
- 24(23). Pronotum coarsely punctate; tegmina bronze ochraceous, apical margins black; 5.5×3 mm. *ornanda*
- 25(22). Apical margins of tegmina concolorous hyaline.
- 26(29). Posterior process distant from scutellum, weakly curved at base.
- 27(28). Suprahumeral long as space between bases, slightly recurved; tegmina yellow hyaline, apical area broadly reddish testaceous, basal part of inner margin narrowly black, sometimes an obscure apical brown spot; legs reddish testaceous, tarsi blackish; 5×3 mm. *imitator*
- 28(27). Suprahumeral a little shorter than space between bases, straight; tegmina pale lurid; legs yellow ferruginous; $5-5.5 \times 3$ mm. *subsimilis*
- 29(26). Posterior process touching apex of scutellum, base strongly convexly elevated, suprahumeral slightly recurved; tegmina vinaceous hyaline, apical area darker; 7.5×4.5 mm. *curvispina*
- 30(21). Tegmina immaculate hyaline except bases.
- 31(34). Suprahumeral long as between bases, robust, tips obtuse, posterior process well separated from the scutellum, convex at base then oblique to apex.
- 32(33). Posterior process arcuate from disk of pronotum to apex, suprahumeral recurved; pronotum ferruginous brown or pale

- castaneous, legs brownish; tegmina very pale ochraceous subhyaline, opaque but not colored at base; 5.5×3 mm. **paria**
- 33(32). Posterior process straight from base, suprahumeral straight; pronotum bluish black, legs black; tegmina bronze ochraceous, basal angle black then whitish spot; $7-8 \times 4.5$ mm. **campbelli**
- 34(31). Suprahumeral half as long as the space between bases, lightly recurved, posterior process weakly sinuate, subhorizontal, not very distant from scutellum and margins of tegmina; slender, black, tibiae dark ochraceous, tarsi black; tegmina stramineous, base black; 4×2 mm. **consobrina**

LIST OF SPECIES

- cognata** Distant, Faun. Brit. Ind. vi, App. p. 149. (1916). Nilgiri Hills, India.
- travancorensis** Distant, Faun. Brit. Ind. vi, App. p. 151. (1916). West Ghats, Travancore, India.
- balteata** Distant, Faun. Brit. Ind. vi, App. p. 151, fig. 108. (1916). Kodaikanal, India.
- scutellata** China, Ann. Mag. N. H. (9), xvi, p. 480. (1925). Atuntze, Yunnan, China.
- varipes** Walker, Jour. Linn. Soc. i, p. 164. (1857). Sarawak, Borneo.
- decipiens** Kirby, Jour. Linn. Soc. Zool. xxiv, p. 165. (1891); Distant, Faun. Brit. Ind. iv, p. 20, fig. 17. (1908). Ceylon.
- imitator* Buckton, Mon. Memb. p. 234, pl. 53, fig. 2. (1903). India.
- flavipes** Kirby, Jour. Linn. Soc. Zool. xxiv, p. 165. (1891); Distant, Faun. Brit. Ind. iv, p. 20, fig. 18. (1908). Margherita, Assam; Nawalapitya, Peradeniya, Kandy, Ceylon.
- canescens** Buckton, Mon. Memb. p. 234, pl. 53, fig. 1. (1903). Tenasserim, Sikhim, Mungphu, Myitta, India. Nongkodjadar, Nusa Kambangan, Java.
- formosana** Matsumura, Annot. Cicad. Japan, viii, p. 15. (1912). Kan-shirei, Formosa Is.
- capistrata** Distant, Faun. Brit. Ind. iv, p. 19, fig. 16. (1908). Margherita, Assam; Ruby Mines, Burma, India.
- recurvata** Distant, Ann. Mag. N. H. xviii, p. 188. (1916). Sarawak, Borneo; Tandjunggadang, Sumatra.
- ornanda** Distant, Faun. Brit. Ind. vi, App. p. 150. (1916). Kodaikanal, India.
- imitator** Kirby, Jour. Linn. Soc. Zool. xxiv, p. 167. (1891); Distant, Faun. Brit. Ind. iv, p. 21, fig. 19. (1908). Pundaluoya, Maskeliya, Weligama, Ceylon.
- subsimilis** Walker, Jour. Linn. Soc. i, p. 163. (1857). Sarawak, Borneo.
- pallipes* Stål, Bid. Memb. K. p. 284. (1869). East Indies.
- curvispina** Stål, Bid. Memb. K. p. 284. (1869); Distant, Faun. Brit. Ind. iv, p. 18, fig. 14. (1908). Maskeliya, Peradeniya, Anuradhapura, Metala, Negombo, Ceylon; Kodaikanal, India.

paria Distant, *Faun. Brit. Ind. iv, p. 18, fig. 15. (1908). N. Bengal; Kodaikanal, India.

campbelli Distant, Faun. Brit. Ind. vi, App. p. 150. (1916). Kodaikanal, India.

consobrina Distant, Faun. Brit. Ind. vi, App. p. 152, fig. 109. (1916). Kodaikanal, India.

* Distant identifies this species with *Controtus paria* Fairmaire; they belong to different genera.

Acanthophyes

Stål, Hemip. Afric. iv, p. 89. (1866); *Lobocentrus* Stål, Hemip. Phil. p. 727. (1870); *Dograna* Distant, Faun. Brit. Ind. iv, p. 24. (1908).

LIST OF SPECIES

- 1(4). Suprahumeral slender, about as long as intervening space, tips acute, posterior process slender, about as long as intervening space, tips acute, posterior process slender, tricarinate median carina percurrent, shorter than tegmina, lobe beneath resting on apex of scutellum; pronotum black.
- 2(3). Tegmina dark vinaceous, decolored fascia beyond middle, base dark ferruginous, three discoidal cells; suprahumeral horizontal, posterior process substraight, apex near margins of tegmina; 7×3.5 mm. **zonatus**
- 3(2). Tegmina pale bronze, base black; suprahumeral weakly oblique, posterior process convex on basal half, apical half testaceous, straight, distant from tegmina; 7×3.5 mm. **suffultus**
- 4(1). Suprahumeral slender, horizontal, not more than half as long as the intervening space, frequently much shorter.
- 5(10). Posterior process distinctly shorter than tegmina, slender, sinuate, tricarinate median carina usually percurrent.
- 6(9). Tips of suprahumeral truncate or broadly rounded, apex of posterior process touching margins of tegmina.
- 7(8). Ferruginous or darker, pronotum tumid; suprahumeral depressed tips truncate front angle rounded, posterior process broadly sinuate at middle, apex decurved, swelling beneath touching apex of scutellum; tegmina fusco-ferruginous; 6.5×4.5 mm. **capra**
- 8(7). Brown or yellowish, suprahumeral blackish, broad, much shorter than the intervening space, tips rounded; posterior process bisinuate, apex decurved, swelling beneath not touching scutellum; tegmina clear hyaline, shining, base brown; $4.5-6$ mm. **chloroticus**
- 9(6). Suprahumeral about half as long as the intervening space, tips acute, posterior process arcuate apical area impinging upon the margins of tegmina; swelling beneath touching apex of scutellum; pronotum fuscous; tegmina ochraceous, base brown; 8×4 mm. **falco**

- 10(5). Posterior process long as tegmina, arcuate and sinuate, basal half thick, apical half slender distant from tegmina, swelling beneath touching apex of scutellum; suprahumeral acute, inconspicuous; tegmina pale yellow, base darker; pronotum tumid, luteus, metopidium rugose; 7×4 mm. **luteus**

LIST OF SPECIES

- zonatus** Stål, Hemip. Phil. p. 728. (1870). Philippines.
suffultus Distant, Faun. Brit. Ind. iv, p. 24, fig. 22. (1908). Bombay, India.
capra Fabricius, Ent. Syst. Suppl. p. 514. (1798). Tranquebar, India.
chloroticus Fairmaire, Ann. Soc. Ent. Fr. (2), ix, p. 86. (1851); Walker, Ins. Saund. Hom. p. 82. (1858). Madrid, Spain; South France.
walkeri Funkhouser, Cat. Hom. p. 338. (1927). Spain.
falco Buckton, Mon. Memb. p. 243, pl. 56, fig. 2. (1903); Funkhouser, Phil. Jour. Sci. x, p. 377, pl. 1, fig. 5. (1915). Malinao, Philippines.
luteus Buckton, Mon. Memb. p. 244, pl. 56, fig. 5. (1903). Adelaide, S. Australia.

Aspasiana

- Distant, Ann. Mag. N. H. xviii, p. 26. (1916).

KEY TO SPECIES

- One shining black species with the tegmina subhyaline, apical area pale brown, base, costal, and radial veins black, legs dark brown; 8-9 mm.
 **impressa**

LIST OF SPECIES

- impressa** Walker, Jour. Linn. Soc. x, p. 192. (168). New Guinea.
carbonaria Distant, Ann. Mag. N. H. xviii, p. 27. (1916). New Guinea.

Polonius

- Distant, Ann. Mag. N. H. xviii, p. 291. (1916).

KEY TO SPECIES

- 1(2). Black; posterior process substraight, tip just passing apex of clavus, tips of suprahumeral acute; tegmina castaneous, base and costal cell black; 7.5×4 mm. **biseratensis**
 2(1). Head longer than broad, finely punctate, hardly pubescent, blackish brown, base highly arched; eyes globular, yellowish gray; ocelli nearer to and even with upper margins of eyes a short carina between; margins of genae acutely angulate below eyes, a small lobule each side of clypeus, the latter short, rounded below margins of genae. Pronotum blackish brown, weakly yellow pubescent,

base deeply impressed each side, convex in front, median carina strongly percurrent subfoliaceous on the disk, (in the type there is a short carina each side extended on the disk from the median carina obliquely backward); humerals triangular, sub-prominent; suprahumeral short, triangular, tricarinate, upper surface irregularly carinate, lightly curved upward and outward, tips blunt, recurved; posterior process slender from base which is slightly separated from the scutellum, basal third straight, middle third obliquely elevated, apical third horizontal and very slender distant from margins of and about as long as the tegmina. Scutellum visible. Tegmina two and a half times longer than broad, ovate, subhyaline, finely wrinkled and punctate, base broadly and costal cell opaque brown; two unequal discal and five apical cells their veins curved inwardly; clavus with margins parallel, two veins the exterior vein curved to inner margin behind middle, apex obliquely truncate. Wings with four apical cells. Sides of chest unarmed, legs simple, femore black, tibiae and tarsi brown, not pilose. Type, female, long. 5 mm., lat. int. sum. corn. 2 mm. (*Froggatt*) **froggatti** new species.

It differs from *biseratensis* in size, color, blunt tips of suprahumeral, longer sinuate posterior process, legs not pilose, and habitat. (Coll. F. W. G.)

LIST OF SPECIES

biseratensis Distant, Ann. Mag. N. H. xviii, p. 291. (1916). Bisert, Siamese Malay State.

froggatti new species, supra. Tweed R., N. S. W., Australia.

Imporcitor

Distant, Faun. Brit. Ind. vi, App. p. 157. (1916).

KEY TO SPECIES

One pale brownish species, suprahumeral and two frontal spots black, posterior process ochraceous, brown spot at base and middle, legs piceous; tegmina opaque yellow, basal area, two transverse bands and apical markings piceous; 7 × 3 mm. **typicus**

LIST OF SPECIES

typicus Distant, Faun. Brit. Ind. vi, App. p. 157, fig. 116. (1916). Nilgiri Hills, India.

Otinotus

Buckton, Mon. Memb. p. 232. (1903); *Convector* Distant, Faun. Brit. Ind. vi, App. p. 153. (1916).

(To be continued)

BOOK NOTICE

Nomenclator Zoologicus, a list of the names of genera and subgenera in zoology from the tenth edition of Linnaeus, 1758, to the end of 1935. Edited by Sheffield Airey Neave. Published by The Zoological Society of London, Regent's Park, London, N.W.8., 1939. Vol. I, A-C. p. xiv + 958. Bound in buckram.

Specimen sheets from this volume indicate the enormous amount of effort that has entered into the compilation of this work that attempts to give a record of the bibliographical origins of the name of every genus or subgenus in zoology since 1758. It should be of particular interest and value to systematists in entomology because the names of the Insecta outnumber all other classes combined. The Mollusca come second and the Arachnida third. An important and useful feature "is the system by which a homonym, of which there are some 18,000, is followed by a cross-reference to any new names that may have been proposed for it." In the entire work approximately 192,000 names of genera or subgenera are included. The total entries amount to more than 225,000, of which about 15,000 are supplementary reference or cross-references, leaving a balance of 210,000, of which 13.8 per cent represent alternative spellings. It is assumed also that the work contains not less than 5,000 names that have been omitted from previous nomenclators and the "Zoological Record."

The complete work will require four volumes, and the remaining three will appear at intervals of about six months. The price for the complete set is 8 guineas, post free. This bears no relation to the initial cost, and it is hoped that it is a price which will enable zoologists, institutions, and libraries to purchase copies.—H. B. W.

THOMAS BOREMAN AGAIN

In the September, 1939, issue of this JOURNAL, reference was made to the entomology of Thomas Boreman's natural histories, based upon such editions as I was able to locate. Following its publication, Mr. Albert E. Lownes, of Providence, Rhode Island, called my attention to the 1730 edition of Boreman, in his possession, and kindly permitted me to examine it. The complete title is "A Description of Three Hundred Animals; viz. Beasts, Birds, Fishes, Serpents, and Insects. With a Particular Account of the Whale-Fishery. Extracted out of the Best Authors, and adapted to the Use of all Capacities; especially to allow Children to Read. Illustrated with Copper Plates, whereon is curiously Engraved every Beast, Bird, Fish, Serpent, and Insect, describ'd in the whole Book. *For every Beast of the Forest is mine, and the Cattle upon a thousand Hills. I know all the Fowls of the Mountains, and the wild Beasts of the Field are mine.* London, Printed by J. T. for Rich. Ware at the Bible and Sun in Amen-Corner, Thos. Boreman the Corner of St. Clement's Lane without Temple-Bar, and Tho. Game at the Bible in Prince's-street, against Stanhope-street End. M.DCC.XXX." (1-9), (1)—213 p. frontis. 1 fold. plate. illustrations. 16.8 cm. \times 9.7 cm.

In my original paper, I ventured the opinion that, in all likelihood, the eleventh edition of 1774 did not differ materially from the 1730 edition. So far as the entomological portion of the book is concerned, this is substantially correct. A comparison of the two shows that they are alike almost word for word. The only change seems to be in the remedy for scorpion stings. In the 1730 edition the remedy is a piece of copper immediately "clapt to the wound." After remaining a while it is removed and the place is annointed with honey and vinegar. In the 1774 edition, oil, in which the scorpion has been infused, is said to be effective. And in addition, it is stated that if the scorpion is surrounded by a circle of burning coals, finding itself unable to escape the pain of the fire, it stings itself two or three times and immediately dies.

In the preface or statement to the reader in the 1730 edition, it is definitely brought out that the book is a compilation designed to interest children and then the compiler says, "If this brief Essay shall any ways contribute to the End propos'd, let God have the Glory, and the Compiler the good Wishes and Prayers of Parents."

I do not know why Boreman's name should be connected with these natural histories in the bibliographies. Perhaps there is something on record naming him as the compiler, rather than Richard Ware or Tho. Game, with whom he was associated in publication ventures.—H. B. W.

BOOK NOTICES

Destructive and Useful Insects—Their Habits and Control. By C. L. Metcalf and W. P. Flint. Second edition. McGraw-Hill Book Company, Inc., New York and London, 1939. Price \$7.50. 23.5 × 15 cm., xvi + 981 p., 584 figs.

This is a completely revised edition of the authors' earlier work of the same title, that was published in 1928. The first edition met with instant favor and there is no reason why the second edition should not be as favorably received as the names of these authors upon any work is a sufficient guarantee of its excellence. There are ten chapters devoted to such topics as, insects as enemies of man, the value of insects to man, external morphology of insects, internal anatomy and physiology, mouth parts, growth and metamorphosis, the orders of insects, control, including insecticides and machinery for control. The remaining thirteen chapters are concerned with insects injurious to specific crops or groups of crops such as corn and related crops, small grains, legumes, cotton, tobacco, truck crops, fruits, citrus plants, shade trees, greenhouse plants and flowers as well as with insects injurious to stored products, those found in the household and those attacking domestic animals and man.

In addition there are keys to the orders of insects in their adult and immature stages, synopses of the more important orders, and numerous (34) field keys for the identification of insects injurious to specific plants. Various tables cover such topics as lethal doses of stomach poisons, poisons to be used for chewing and sucking insects, fumigants, etc.

Pages 332 to 910, by far the greatest portion of the book, are devoted to 370 injurious species or groups of species and exclusive of the field keys, the text about each species or group embraces the importance and type of injury, plants attacked, distribution, life history, appearance and habits, and control measures. All through the book stress is laid upon recognition of the pests and their control and the authors have made these two features as adequate as existing information permitted.

In addition to being a text book for college introductory courses

in entomology, this encyclopedic work is also a reference book for farmers, fruit growers, county agents, entomologists and persons who have any interest in entomology at all or who are brought into contact with insects. It is not only comprehensive but it is also well indexed and illustrated, and were I permitted only one book on economic entomology on the traditional desert island, I am of the opinion that I would select this one.

Although the book is entitled "Destructive and Useful Insects," only 32 of the 910 pages of text are devoted to the value of insects to man, and one is inclined to wonder why the word "useful" was employed in the title, in view of the devotion of almost the entire text to injurious insects.—H. B. W.

Working with Nature. By Eleanor King and Wellmer Pessels. Harper & Brothers, New York, London, 1939. \$1.20. 19.5 × 13 cm., xv + 181 p., 60 illus.

In the June, 1939, issue of this JOURNAL three entomological books for children, by these authors, were favorably noticed and now we have another, largely entomological, by the same industrious authors, who have a flair for interesting and truthful writing on natural history subjects.

Working with Nature is a science reader for seventh and eighth grade students and it is designed to lead up easily to an understanding of the importance of wild life conservation, by showing what is going on in the everyday lives of creatures all around us and the relationships between these creatures and plant life. Insects, because of their abundance and because they are easily studied, furnish many of the examples, used by the authors in developing their subject, although other animals such as frogs, crayfish, birds and small mammals are by no means neglected. The subject matter is presented in the form of short, readable essays on such topics as "What's Going on in Your Dooryard," "In Debt to the Insects," "Butterflies and Moths," "In Pond and Brook," "Saving the Ducks!" "What the Fur-Bearers Mean to Us," etc. I think that the authors have achieved their aim in writing this book and that youthful science readers will absorb from it, unknowingly, the elementary principles of sound conservation. This is no "dry as dust" science reader, but an interesting and lively presentation.—H. B. W.

Blatchleyana—II. A Supplementary List of the Published Writings of W. S. Blatchley. Indianapolis, The Nature Publishing Company, 1939. 50 cents. 46 p., 3 pl.

This supplement to "Blatchleyana—1930" contains a list of Dr. Blatchley's published writings, and a chronology of his life from June 30, 1930, to September 1, 1939. In addition there are included extracts from some of his books, dedications and appreciations, and his reminiscences of James Whitecomb Riley. Entomologists and others who have never had the pleasure of knowing Dr. Blatchley personally, will be grateful for the interesting and intimate glimpses of his life, his thoughts, his philosophy and his beliefs, which this supplement affords.—H. B. W.

A Laboratory Guide in Entomology. For Introductory Courses.

By Robert Matheson, Ithaca, New York. Comstock Publishing Company, Inc., 1939. 11×8 inches. 135 p. 48 pl. Stiff paper covers. \$2.00.

This guide includes 28 studies covering the external and internal structures of insects, metamorphosis and growth, identification, wing venation, sound producing organs, studies of insects as social groups, pollinators, and in their relation to man, insect control, and the collection, mounting and preservation of insects. Its coverage for an introductory course in entomology is highly satisfactory and, I suspect, more adequate than is actually given in many places. Its numerous plates with their unlabelled figures together with the directions and explanations in the text would almost seem to make an instructor unnecessary, but in practice, such a degree of perfection is seldom attained.

With this laboratory guide, a student who has no skill in drawing what he sees, may label and interpret the drawings that are furnished for such purposes, thus saving for other things a lot of time and effort formerly devoted to bad, and in some cases, horrible draughtsmanship.

Instructors, as well as students, of entomology, will find Dr. Matheson's "guide" authentic and labor saving.—H. B. W.

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The New York Entomological Society

Organized June 29, 1892—Incorporated June 7, 1893

Certificate of Incorporation expires June 7, 1943

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

Members of the Society will please remit their annual dues, payable in January, to the treasurer.

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